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ABSTRACT

This document contains conclusions, recommendations, a summary of results, and interpretations of the 1981 Mathematics Assessment Program. The Assessment Program involved the production of achievement tests and teacher questionnaires for the third, sixth, ninth, and twelth-grade students. These were a test related to general mathematics skills, and tests reflecting the Mathematics 300 and Mathematics 301 courses. Performance in Measurement and Geometry was disappointing across all grade levels. Grade three showed satisfactory performance on whole number computation in addition and multiplication, but was weak on inverse operations of subtraction and division. Interpretation of bar graphs, linear measurement, and nonnumerical geometry was well done, while numerical applications in geometry caused difficulty. Major findings are also listed for grades six, nine, and the three testing levels of grade twelve. Detailed analysis and discussion of sample problems are presented in discussions of each testing group, and aspects of the teacher survey results are included. (MP)

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MANITOBA MATHEMATICS ASSESSMENT PROGRAM 1981

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FINAL REPORT

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MANITOBA
DEPARTMENT OF EDUCATION

MANITOBA MATHEMATICS ASSESSMENT PROGRAM 1981

FINAL REPORT

A REPORT OF THE

MEASUREMENT AND EVALUATION BRANCH

DEPARTMENT OF EDUCATION

PROVINCE OF MANITOBA

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THE MANITOBA MATHEMATICS ASSESSMENT PROGRAM

The Assessment Program involved the production of achievement tests at each of grade levels 3, 6, 9, and 12. At the grade 12 level there were three tests: a test related to general mathematics skills and tests reflecting the Mathematics 300 and Mathematics 301 courses. Further, teacher questionnaires were developed for the four grade levels. Following the Assessment the Preliminary Report was produced in four volumes: I. Grade 3 Test Data, II. Grade 6 Test Data, III. Grade 9 Test Data, and IV. Grade 12 Test Data. The conclusions and recommendations at all grade levels are consolidated in this, the Final Report.

A major part of the development of these materials was due to the Mathematics Contract Team comprising:

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PREFACE

The Preliminary Report (four volumes) is the first of two reports on the findings of the Mathematics Assessment Program 1981. It contains a description of the program and details of student performance on several mathematics topics and on actual test items. The conclusions and recommendations, along with a summary of the results and interpretations, are presented in the Final Report. These are based on the interpretations of panels of teachers, other educators, and members of the public. Regional meetings, of teachers for the discussion of results and conclusions, are scheduled for March of 1982.

The purpose of the Preliminary Report is to provide detailed information on student performance for use by classroom teachers in forming judgements about the instructional program. All data are based on the provincial sample as a whole; no individuals, schools, or divisions are identified. The Final Report presents the conclusions based on the provincial result. Teachers and other educators are encouraged to review the conclusions and recommendations for applicability to their programs and to their own students. A review of the objectives assessed by the tests is recommended prior to interpretation of results at the local level.

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- The Mathematics Contract Team which gave professional assistance to all aspects of the program.
- The Joint Committee on Evaluation which provided guidance throughout the program.
- The Mathematics Technical Advisory Committee which advised on test production and analysis of results.
- The teachers and others who participated in the review of objectives, and those who assisted in the interpretation of the results.
- The school administrators, teachers, and students who were involved in the pilot testing.
- The divisions and schools that released their teachers to assist in the program.
- The staff of the Measurement and Evaluation Branch and of other Branches of the Department of Education who provided necessary support throughout the program.

A WORD OF CAUTION ABOUT THE ASSESSMENT PROGRAMS

All measurements of human skills and abilities are subject to errors of measurement. These errors can occur in a number of ways: the specification of skills and objectives, the selection of materials and production of test questions, the weighting of questions, the interpretation of questions by students, the presentation of results, and the interpretation of these results. In the assessment program, effort has been made to minimize the error; nevertheless, the results should be regarded as estimates of the performances of students. Individual student diagnosis or grading on the basis of the tests should be attempted only in conjunction with other tests and assessments. Furthermore, the intent of the assessments is to obtain estimates of the performance of Manitoba students in general.

In the interpretation of results it is not possible to conclusively attribute performance strengths and weaknesses to specific aspects of curriculum and instruction. In addition, a variety of societal factors must be considered. The data presented in this report provide initial estimates of the performance of Manitoba students, and the conclusions and recommendations based on these results represent the combined thinking of a number of groups and committees.

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CHAPTER I

OVERVIEW AND HIGHLIGHTS OF THE MATHEMATICS ASSESSMENT

The assessment of mathematics at the grade 3, 6, 9, and 12 levels is the final assessment of the initial cycle in writing, reading, and mathematics. Additional assessments were conducted in science, grades 5, 8, and 11, and Chemistry 200 and 300.

In May of 1981 students in grades 3, 6, and 9 wrote tests applicable to their grade level, while students in grade 12 wrote a "general" mathematics test reflecting basic mathematical skills and consumer applications, and students taking Mathematics 300 and 301 also wrote tests applicable to these courses. For the provincial survey, approximately 10 percent of student papers were selected for the 3, 6, 9, and 12-general tests, and 20 percent for the Mathematics 300 and 301 tests.

For their own use schools could request that additional students write the tests. An estimated 90 percent of students in grades 3, 6, and 9 wrote the tests and 50 percent at the 12 level wrote the general test and 83 percent wrote the 300 and 301 tests.

The tests were designed to assess student knowledge and understanding of mathematics in a number of topic areas. The objectives for assessment were based on the Manitoba curriculum, and reflected the recommendations of teachers from throughout the province. The results provide information for curriculum review and development at the provincial and local levels, as well as for teachers and other educators to assist in the review of their programs.

NATURE OF THE ASSESSMENT

The Manitoba mathematics program consists of a large number of skills and objectives categorized in major topic areas; the topics become more specific in, and are unique to, the Mathematics 300 and 301 courses. There are six topic areas delineated for the grade 3, 6, 9, and 12-general tests, although not all tests contained items for each topic area.

Number systems, operations, and properties--conducting calculations and using operations with numbers.

Measurement--using the appropriate measures in metric and determining such things as length, area, volume, and mass.

Geometry--recognizing shapes and using notions of relative position and angle.

Algebraic concepts--understanding and manipulating of algebraic symbols and expressions.

Graphing and Statistics--interpreting of graphs and computing of statistics, such as average.

Consumer applications--calculating and estimating solutions to consumer-oriented problems relating to interest, tax, cost, and discount.

The Mathematics 300 and 301 tests contained items relating to more specific topics. These topics are:

Mathematics 300	Mathematics 301
Relations and Functions	Sequences
Exponential and Logarithmic Functions	Exponents
Circular Functions	Logarithms
Trigonometric Identities	Trigonometry
Trigonometry	Polynomials, Rational Expressions, and Quadratic Relations
Systems of Equations	
Inequalities	Ration, Proportion, and Variation
Progressions	Interest and Annuities
Permutations, Combinations, and Binomial Theorem	Mathematics of Chance
	Statistics

The items for all tests were further designated according to the type of thinking required. Three levels were specified.

Knowledge and computation--including knowledge of mathematical facts and terms, and ability to perform typical calculations.

Comprehension--comprising the understanding of concepts, principles, and algorithms, and the ability to transform mathematical notions in problems from one mode to another.

Application--including the ability to solve routine problems using standard algorithms, and to analyse data or recognize patterns. The student decides what operations or algorithms to apply.

ASSESSMENT PROCEDURES

The assessment began with the identification of grade levels and test topics. Teachers and mathematics specialists devised the objectives and test items. Approximately 200 teachers from throughout Manitoba participated in the review and selection of objectives for assessment.

The results of the provincial sample were analysed and reported to schools in September of 1981; the Preliminary Report was published in four volumes, one for each grade level assessed. Since these data were not based on any previous assessments, interpretations of the results were determined with the assistance of 52 teachers, administrators, and trustees.

The Final Report contains a summary of the results and interpretations at all grade levels. As well, it includes the conclusions and recommendations based on the results.

MAJOR FINDINGS OF THE STUDENT ASSESSMENT

Grade 3

Student performance was satisfactory on whole number computation in addition and multiplication, but on the inverse operations of subtraction and division it was weak. Interpretation of bar graphs, linear measurement, and nonnumerical geometry was well done, while numerical applications in geometry caused difficulty.

Grade 6

Basic computation with whole numbers was generally well handled although zeros caused difficulties in particular types of multiplication and division exercises; students did not perform well on computation with fractions. Some understanding of symmetry and motion geometry was demonstrated, but geometric terminology was poorly understood. While students were able to estimate the length of a crayon in centimetres, they were unable to make conversions of units within the metric system or to calculate the area or perimeter of a rectangle.

Grade 9

Student performance on basic operations with integers, fractions, and decimal fractions was marginally satisfactory, and on operations with absolute value a weakness. Students were able to find the area and perimeter of a rectangular region, but otherwise showed little understanding of geometric concepts and terminology. Certain types of algebraic skills, such as simplification and substitution, were satisfactory, but others were at an unsatisfactory level: exponents, terminology, and equation solving.

12-General

Student performance was generally satisfactory on consumer applications of mathematics and on graphing and statistics. Performance by students who had no grade 12 mathematics was not strong on basic operations with integers and percents, but all groups did well on recognizing appropriate use of everyday units in the metric system. Geometry performance, except for students enrolled in Mathematics 300, was considered weak.

Mathematics 300

The performances of Mathematics 300 students on the Permutations, Combinations, and Binomial Theorem subtest were very satisfactory, and on Exponential and Logarithmic Functions, Trigonometry, and Trigonometric Identities were satisfactory. On the remaining five topic areas performance was considered marginally satisfactory.

Mathematics 301

Performance by Mathematics 301 students in the topic areas of Sequences and Exponents was considered satisfactory. Results in the other required areas were marginally satisfactory. In the option topics of Interest and Annuities, Mathematics of Chance, and Statistics, performances were rated marginal, marginal, and unsatisfactory respectively.

Trend Across Grade Levels

Performance in Measurement and Geometry was disappointing across all grade levels. While a few bright spots can be identified, the general conclusion is one of weakness in these areas.

MAJOR FINDINGS OF THE TEACHER SURVEY

These findings are based on information provided by teachers responding to the questionnaires administered in conjunction with the student assessment. Due to commonalities in the programs, grade 3 and 6 teacher responses are treated as one group, and grade 9 and 12 as another.

Grades 3 and 6

Virtually all elementary school mathematics teaching takes place in a self-contained classroom by a nonspecialist teacher, and about 20% of teachers are teaching more than one grade level within that classroom. At both grade levels much time is spent in having students work individually, but both large and small group instruction is used.

The 1978 K-6 Mathematics Curriculum Guide has been well received and is being used. Teachers favor the current policy of several recommended textbooks from which they may choose. Better textbooks, more manipulative materials, and more time were some of the items which teachers saw as important to their mathematics instructional programs.

The use of calculators received a favorable response, but it was clearly indicated that they should not be used to replace the learning of basic arithmetic skills. Calculators should be used as a support tool in a variety of mathematics situations.

Evaluation in the classroom follows traditional patterns with an emphasis on teacher made tests and day-to-day observation of students. However, the student assessment program was well received. Teachers generally felt that the objectives tested and the difficulty level were appropriate.

Grades 9 and 12

Over two thirds of grade 12 mathematics teachers teach primarily mathematics including at the grade 10 and 11 levels--80% or more of their teaching load. Slightly over half of grade 9 mathematics teachers indicated that 60% or more of their teaching load was mathematics. Over 70% of grade 12 mathematics teachers indicated that Mathematics 300 and 301 was taught on a semester basis, whereas less than 20% indicated this at the grade 9 level. Generally teachers feel that less learning takes place in the semester system as opposed to the full year system.

Individual student work and lecture/demonstration are the primary activities within the classroom at both levels. Grade 9 teachers indicated that the 7-9 Mathematics Curriculum Guide has been well received and is used.

Calculators were seen as a tool to be used, particularly in the early years (grades 7-10) of the secondary school. At grade 12 level teachers were divided on the use of the calculator as a substitute for the use of mathematical tables.

Evaluation in the classroom follows traditional patterns with emphasis on teacher-made tests and daily observations of students. The teachers viewed the assessment program and student tests favorably. The difficulty levels were seen to be appropriate and there was overall satisfaction with the tests at the grade 9 and 12 levels.

At the Mathematics 300 level three topic areas were recommended for a decreased emphasis and none for an increased emphasis. In the 300 program as a whole there are differences in the goals of teachers: those areas indicated as essential by some were considered only slightly useful by others. Only three topic areas were identified strongly as essential, and one, consumer mathematics, was rated by a significant number of teachers as less than useful.

For Mathematics 301 no consensus was achieved in regard to an overall goal statement, but some common goals can be derived from the ratings given. Algebraic skill development and consumer mathemtics both rated highly, while formal proof was thought unnecessary.

SUMMARY OF RECOMMENDATIONS

The recommendations arose from a synthesis of the student assessment results and the teacher survey, and are presented in Chapter IX of this report. A summary of these recommendations is provided below.

- That topics in geometry and measurement receive more attention in the classroom and in professional development.
- That, at each grade level, concepts and skills from earlier grade levels be part of ongoing review, in part by embedding them in a problem solving context.
- That the use of calculators in the elementary school be encouraged as a supportive tool in areas other than basic arithmetic.
- That correct mathematical terminology be used in the classroom.
- That the current trend toward more emphasis on problem solving activities be continued and encouraged.
- That computer education in its various forms be closely monitored as microcomputers become more available at all levels, including the elementary school. Computer education should be encouraged.

To those responsible for program at the specific grade levels:

Grade 3

- That subtraction and division receive appropriate attention by teachers and that they be taught as inverse operations of addition and multiplication respectively.
- That more emphasis be placed on applications. In some cases this may mean more time, but alternative approaches should also be considered, e.g., embedding application in review.

Grade 6

- That the topic of place value be reviewed at each grade level and that students be given practice in estimating results.

Grade 9

- That students be given more opportunities to do practical problems involving Pythagorean Theorem.
- That the curriculum guide, 7 - 9 Mathematics (1979), be followed by teachers and that core topics given in the guide be given priority over option topics.

Mathematics 300

- That the following be reviewed: 1) the mathematics background required for a student to be successful in Mathematics 300, and 2) the counselling of students to enroll in Mathematics 300.
- That the objectives of Mathematics 300 be closely examined in the context of teacher expectations of students, university entrance requirements, time allotments and organization, and the availability of calculators and/or computers.
- That teachers stress the properties of logarithmic and exponential functions over computations (which can be readily performed with a calculator).

Mathematics 301

- That the objectives of Mathematics 301 be closely examined in the context of teacher expectations of students, higher education and career goals of students, time allotments and organization, and the availability of calculators and/or computers.

Teacher Resources and Equipment

- That schools be urged to supply, and teachers to use, more supporting manipulative and reference material in elementary mathematics.
- That the present textbook adoption policy of teacher selection from among authorized texts be continued.
- That the present curriculum guides, K - 9 Mathematics, or guides with similar characteristics, continue to be available to mathematics teachers at these levels.

CHAPTER II

THE MATHEMATICS ASSESSMENT PROGRAM

An assessment program involves a number of distinct tasks, one of which is the reporting of results. The actual utilization of the assessment extends beyond that of the recommendations specified in the report. A major part of the utilization is the use of the tests by teachers in their classrooms. One such use is the review by teachers of their instructional programs, based in part on the performance of their students and on the provincial results.

FORMAT OF THE REPORTS

The first chapter of this, the Final Report, provides a brief overview of the assessment procedures, findings, and recommendations. This material is a distillation of what follows in the remainder of the report, namely: achievement results and their interpretation, by grade level; results of the Teacher Survey; and conclusions and recommendations.

The raw data on student achievement were previously published without interpretation in the Manitoba Mathematics Assessment Program 1981 Preliminary Report (4 volumes). Since publication of the Preliminary Report, the data have been reviewed by the Interpretation Panels, the Contract Team, and the Technical Advisory Committee. The views of these groups have been incorporated into the summary presentation of results and interpretations provided in this document. All results have been reported on a provincial basis only, with no identification of individuals, schools, or school divisions.

BACKGROUND TO THE ASSESSMENT

The Mathematics Assessment Program is part of the overall Manitoba student assessment program, as recommended by the Joint Committee on Evaluation and approved by the Minister of Education. The purposes for the assessment programs are:

1. To provide benchmark indicators about the level of student achievement in the Province of Manitoba.
2. To obtain data on student achievement that will assist in curriculum and program improvement at the provincial and local level.
3. To assist school divisions in student and system evaluation.
4. To help teachers improve their student evaluation skills.

Mathematics Topics and Cognitive Levels

The mathematics tests were designed to assess the kinds of understanding, skills, and knowledge that are included in the Manitoba mathematics curricula and that were given priority for assessment by Manitoba teachers. Tests were developed at the grade 3, 6, 9, and 12 levels. On the basis of a sample of students selected from public schools throughout Manitoba student performance was determined on the objectives identified for assessment.

Furthermore, the importance of levels of thinking was recognized and three levels were specified for the assessment. The three cognitive levels are described below with actual test items illustrating each.

Knowledge and computation. Knowledge of mathematical facts and terms, and ability to use standard algorithms for the basic operations on the set of real numbers. The two examples below are from the grade 3 and 9 tests respectively.

$2 \times 6 = \square$

$\sqrt{441}$ is equivalent to

A) 19
B) 29
C) 31
D) 21
E) 41

Comprehension. The second cognitive level assessed was the understanding of concepts, principles, and algorithms, and the ability to read and interpret problems and to transform mathematical notions in problems from one mode to another. The examples depicted are from the grade 6 and 9 tests respectively.

By rounding to the nearest ten, an estimate of 132 + 89 would be

A) 220
B) 210
C) 200
D) 190

If $x = 4$, $y = 2$, and $z = 0.5$, the value of $2xy^2z$ is

A) 16
B) 32
C) 64
D) 128
E) 256

Application. The third level included the ability to solve routine problems, apply standard algorithms in problem situations, analyse data, and recognize patterns: the student decides what operations or algorithms to apply. The following examples are extracted from the grade 3 test and the general test at the grade 12 level.

Write the number which comes next. 40, 35, 30, 25, 20 _____

A litre of asphalt paint will cover about 6 m^2 of surface area. The paint is sold in cans of 5 litres only. How many cans are needed to paint a driveway 15 m long and 3 m wide?

A) 9
B) 8
C) 7
D) 1
E) 2

Mathematics Topics. On the recommendation of the Joint Committee six tests were produced, one for each of grades 3, 6, and 9, and three for grade 12: one based on "general" mathematics objectives and one each based on the mathematics 300 and 301 programs. The mathematics topics for the grade 3, 6, 9, and 12-general tests were equivalent; distinct topics for the 300 and 301 tests were delineated. The number of test questions at each grade level pertaining to the topic areas and cognitive levels are specified in Tables II-1, -2, and -3.

TABLE II - 1

Numbers of Test Items For Topics and Cognitive Levels

Topic Areas	Grade Level Tests Within Cognitive Levels											
	Knowledge and Computation				Comprehension				Application			
	3	6	9	12 General	3	6	9	12 General	3	6	9	12 General
Number Systems, Operations,	31	37	13	10	16	31	9	5	14	11	3	
Measurement	10			2	6	9		2	8		3	
Geometry			1	2	7	6	3	3	2		2	2
Algebraic Concepts			11			27	4				4	
Graphing and Statistics							3	3	3	4	2	2
Consumer Applications							3					12
Totals	41	37	25	14	32	46	42	20	27	15	14	16

The tests for Mathematics 300 and 301 are course specific in specialized content and thus the topic areas employed for the other tests were inappropriate. Separate topic

TABLE II - 2

Mathematics 300: Numbers of Test Items For Topics and Cognitive Levels

Topic Areas	Knowledge and Computation	Comprehension	Application
Relations and Functions	1	7	1
Exponent and Logarithmic Functions	2	2	2
Circular Functions	2	3	1
Trigonometric Identities			3
Trigonometry	1	1	3
Systems of Equations		1	1
Inequalities			3
Progressions		1	2
Permutations, Combinations and Binomial Theorem	2	3	
Totals	8	18	16

areas were identified for each of these courses based directly on the provincial curriculum guides. Both courses are considered to require approximately 12% of a student's time, or about 110-120 class hours annually. The three cognitive levels outlined for the other tests were used in the analysis, although a number of categories contain too few items for meaningful interpretation.

TABLE II - 3

Mathematics 301: Numbers of Test Items For Topics and Cognitive Levels

Topic Areas	Knowledge and Computation	Comprehension	Application
Sequences		3	1
Exponents	3	4	
Logarithms	4	1	
Trigonometry	1	1	4
Polynomials, Rational Expressions and Quadratic Relations	7		1
Ration, Proportion, and Variation	2	4	1
Interest and Annuities		1	1
Mathematics of Chance	1	1	2
Statistics	1	1	
Totals	19	16	10

STEPS IN THE ASSESSMENT PROGRAM

The procedures of the Mathematics Assessment Program were similar to those for previous assessments in writing, reading, and science. Following selection of mathematics as the area for assessment, a Mathematics Technical Advisory Committee (TAC) and a Mathematics Contract Team were established to assist in the actual production of the tests and reporting of the results.

The TAC consisted of three teachers of mathematics for each of grades 3 and 6, four for grade 9, and three for each of the 300 and 301 levels (the grade 12 teachers also assisted in the general test at the grade 12 level). One person from the Measurement and Evaluation Branch served as chairperson of the TAC. Department of Education mathematics curriculum staff and the Contract Team acted as consultants to the TAC.

The Mathematics Contract Team included one mathematics teacher and four university mathematics education specialists.

The major steps involved in the Assessment Program are outlined below.

Step One: Identification of Objectives

The Contract Team produced a list of mathematics objectives for each of the four grade levels. These were derived from the Manitoba mathematics curriculum. Objectives appropriate to each grade level and to the immediately preceding levels were identified for grades 3, 6, and 9. Three distinct sets of objectives were identified at the grade 12 level: "general" mathematics objectives reflecting basic mathematical skills and consumer applications, and mathematics 300 and 301 objectives based on current programs in these courses.

The TAC provided an initial review of the objectives and of the procedures for selection of objectives to be tested.

Step Two: Selection of Objectives

Teachers of mathematics from districts and divisions throughout Manitoba supplemented and rated the importance of the objectives for instruction and for assessment. They further indicated the information that would be useful to collect from teachers in conjunction with the student test data.

Seven regional meetings were held in various locations in Manitoba for this purpose. The data collected at the meetings was compiled and used in the selection of objectives for the tests.

Step Three: Production of Test Items

The TAC recommended the format and the specifications for the tests based on the input from teachers at the regional meetings. The Contract Team with the assistance of the TAC produced test items according to the specifications. The Contract Team was also guided by the need to produce items at various cognitive levels.

The test items were reviewed and modified by the TAC before inclusion in pilot tests. This was done to ensure accuracy of the wording, appropriate readability, and technical quality of the items.

Step Four: Pilot Testing

The pilot tests were administered to several classes of students at each grade level. Since at the time of pilot testing students in the four grades were approximately mid-way through the program additional classes at grades 4, 7, and 10 and students who had previously completed Mathematics 300 and 301 were tested with the appropriate tests.

The results of the pilot tests were analyzed to determine the adequacy of test items. Items were modified or deleted as necessary by the TAC and rewritten by the Contract Team. The final versions of the tests were reviewed and edited by the TAC.

Step Five: Provincial Administration of Tests

The tests were administered on the morning of Wednesday, May 13, 1981, to students in grades 3, 6, 9, and on the morning of Thursday, May 28, 1981 to students in grade 12.

Teachers could request that the tests be written by students in addition to those designated for the provincial sample (sufficient copies of tests were provided for this purpose). The scoring of student tests by teachers provided them with an indication of their students' performance, which could be reviewed in conjunction with the provincial results presented in the Preliminary Report. It is estimated that over 90 percent of students in grades 3, 6, and 9 wrote the tests. Over 50 percent of students in grade 12 wrote the general test, and approximately 83 percent of mathematics 300 and 301 students wrote the 300 and 301 tests.

Approximately 10 percent of the students in grades 3, 6, and 9 in Manitoba public schools were randomly designated for the provincial sample. Approximately 10 percent of grade 12 students were randomly selected for the general test, and 20 percent of those enrolled in Mathematics 300 or 301 at the time of testing were selected for the grade 12 general test and the appropriate one of the 300 or 301 tests. Table II-4 indicates the provincial sample of tests at each grade level. The actual sample of student tests analyzed was approximately 83 percent of the designated sample. The sample loss was due primarily to student absence and transfer, and varied according to grade level and group tested.

TABLE II - 4

Number of Students in the Provincial Sample

Grade Level Test	Number of Students Eligible	Student Tests Scored For the Sample			
		Number of Females	Number of Males	Total Number	Percentage of Students Eligible
3	15,069	666	695	1392	9.24%
6	15,318	667	706	1401	9.15%
9	14,604	618	656	1298	8.89%
12-General only	7,460	253	228	495[b]	6.64%
12-300 and General	3,105	241	263	513	16.52
12-301 and General	2,462	201	163	372	15.18

[a]The total is slightly larger than the sum of the numbers for females and males because some students did not indicate their gender.

[b]This includes students who took Mathematics 300 or 301 in a previous semester.

Those test papers selected in advance for the provincial sample were scored by the Department of Education. At grades 6 and 12 all items were multiple choice format with either four or five choices. Answers were placed on a standard answer sheet for machine scoring. In grade 9, all questions were multiple choice except for two items on geometric construction. These items were completed in the test booklet using either compass and straightedge or mira. A variety of approaches were considered acceptable, and scores were transferred by Department of Education personnel to the standard sheets used for the rest of the test.

This same scoring procedure was used at the grade 3 level, where all questions were answered within the test booklet. The format of grade 3 items varied considerably and included completion items, written answer computations, and multiple choice questions involving circling the correct answer.

Step Six: Reporting of Results

A summary of the results for all grade levels was reproduced in each of the four volumes of the Preliminary Report. A particular volume also presented detailed results of student performance on the topics, cognitive levels, and test items for one grade level. The volumes are: I Grade 3 Test Data, II Grade 6 Test Data, III Grade 9 Test Data, and IV Grade 12 Test Data. Since each volume provided a summary of all grade levels appropriate volumes of the report were distributed in September to schools containing classes at that grade level.

The Final Report presents a summary of the results at all grade levels and details of the interpretations, conclusions, and recommendations.

Step Seven: Interpretation of the Results

Since no adequate performance criteria were available from previous years the actual performance of students was evaluated by an Interpretation Panel for each of the six tests. These Interpretation Panels included classroom teachers, administrators, and school trustees. Their input was used by the TAC and Contract Team to make the conclusions and recommendations presented in the Final Report.

The members of the Interpretation Panel for the particular test reviewed the test items and determined two levels of performance:

> "Adequate" performance--the minimum percentage of students in the province that you think must answer an item correctly in order for the performance to be considered satisfactory. Performance below the adequate level would, in your opinion, be considered indicative of a weakness.
>
> "Desirable" performance--the percentage of students in the province that you would like to see complete an item correctly; a goal toward which to strive. Performance at or above the desired level would, in your opinion, be considered indicative of a strength.

The item estimates for adequate and desirable performance were averaged for all items belonging to a particular topic area or subtest, thus providing estimates for the subtest. This was done without recourse to the actual data of the provincial samples.

Interpretation Panel members rated the performance of the provincial sample on each subtest by comparing actual achievement with their estimated adequate and desirable levels of performance. The following five-point scale was used:

STRENGTH:	Actual achievement is well beyond what is acceptable, and at or above what is desirable.
VERY SATISFACTORY:	Actual achievement is somewhat beyond what is acceptable, but below what is desirable.
SATISFACTORY:	Actual achievement corresponds to that is acceptable.
MARGINAL:	Actual achievement is somewhat below what is acceptable but not to the point of being Totally unacceptable. This is considered

to be an area where some additional work seems necessary.

UNSATISFACTORY: Actual achievement is well below what is acceptable. This is considered to be an area of weakness and remediation is deemed necessary.

FRENCH LANGUAGE VERSIONS OF THE MATHEMATICS TESTS

The Joint Committee on Evaluation recommended that the test instruments for mathematics be produced in both the French and English languages at the grade 3, 6, and 9 levels (due to the small numbers of students in grade 12 receiving their mathematics instruction in French, only English-language tests were produced at this level). Production of two versions of an assessment instrument in different languages is a complex procedure involving more than mere translation. The Mathematics TAC included French language mathematics teachers and the Bureau de'lEducation Francaise mathematics consultant. These members assisted in test development, and made recommendations on test construction, based on imput from a meeting of French language teachers of mathematics. Additional French language teachers of mathematics were hired to assist in the translation.

Teachers had the option of testing their students in either the English or French language at grade 3, 6, and 9 levels. Approximately 700, 510, and 320 French language tests were requested for grade 3, 6, and 9 students respectively. Students results are reported on a provincial basis only. Thus there is only one set of results combined for the English and French language students in the provincial sample.

THE TEACHER SURVEY

In addition to the assessment of student achievement, teachers at the four grade levels were surveyed to gain information on classroom organization, practices, use of resources, and a number of other variables. This survey and its findings are discussed in Chapter VIII of the Report.

CHAPTER III

GRADE 3 RESULTS

The grade 3 test consisted of 100 items divided among fifteen subtests. Nine of the subtests dealt with number concepts and operations, four with measurement, one with geometry, and one with graphing. All of the skills and concepts that were tested are found in the grade 3 section of the provincial curriculum guide.

A total of 1392 grade 3 students, 666 females and 695 males, formed the provincial sample for the assessment program. This is approximately 92% of the 10% sample designated for the provincial survey.

ACHIEVEMENT RESULTS

The actual results together with the ratings of the Interpretation Panels are presented in Table III-1. Each of the subtests are discussed in turn. For details of student performance on the items refer to Volume I of the Preliminary Report.

The Interpretation Panel ratings are based on a five-category scale: Strength, Very Satisfactory, Satisfactory, Marginal, and Unsatisfactory. A description of these categories and the rating procedure is given in Chapter II (p.13).

Table III-1

Grade 3: Results on Subtests

	Subtest Within Topic Area		No. of Items	Average Percentage Correct	Interpretation Panel Rating
I.	Number Systems, Operations, and Properties				
	I.A	Concept of Whole Numbers	3	82	Very Satisfactory
	I.B	Place Value	6	74	Satisfactory
	I.C1	Addition of Whole Numbers	8	78	Satisfactory
	I.C2	Subtraction of Whole Numbers	7	63	Marginal
	I.D1	Multiplication of Whole Numbers	12	79	Satisfactory
	I.D2	Division of Whole Numbers	7	62	Marginal
	I.E	Fractions and Decimals	4	52	Unsatisfactory
	I.G	Patterns	6	62	Marginal
	I.H	Applications	8	59	Unsatisfactory
II.	Measurement				
	II.A	Linear Measurement	12	70	Satisfactory
	II.BC	Area, Volume, and Capacity	4	50	Unsatisfactory
	II.EFG	Money, Time and Temperature	7	59	Unsatisfactory
	II.H	Application	4	26	Unsatisfactory
III.	Geometry		9	75	Satisfactory
IV.	Graphing		3	79	Very Satisfactory

I. Number Systems, Operations, and Properties

I.A Concept of whole numbers. Performance on this subtest was viewed as being "very satisfactory". It assessed student ability to order a set of whole numbers. Over 75% of the students answered all three items correctly. For the remaining 25% the item involving whole numbers less than 100 (23, 96, 5, 67) proved to be the easiest, while the item involving whole numbers greater than 500 (729, 403, 927, 630) was the most difficult.

I.B Place value. This subtest comprised six items, three involved translating a standard numeral into expanded notation and three dealt with identifying the place value position of a digit in a given numeral. Student performance was rated "satisfactory".

Each of the items on translating a numeral into expanded notation was answered correctly by 81% or more of the students. Students were less successful on the items dealing with identification of place value. Two of these items were answered correctly by less than 65% of the respondents. The following item was the most difficult:

(17.) How many tens in 925?

- ☐ 9
- ☐ 2
- ☐ 5

Only 53% of the respondents answered the above correctly. Approximately 41% of the respondents thought that there were 9 tens in 925.

I.C1 Addition of whole numbers. Performance on addition of whole numbers was viewed as being "satisfactory". Six of the eight items on this subtest involved calculating the sum of two or more whole numbers. Each of these items was answered correctly by 80% or more of the students. The items involving addition of two whole numbers less than 100 (35 + 43 and 67 + 28) were the easiest, while the items involving three whole numbers (217 + 75 + 40 and 353 + 82 + 43) were the most difficult. Approximately 10% of the errors made in determining the sum of 217 + 75 + 40 were attributable to improper renaming and regrouping.

The remaining two items on the subtest dealt with estimating the sum of two whole numbers. The percentage of correct responses for these items varied greatly. Approximately 74% of the respondents were able to correctly estimate the sum of 79 + 53. However, only 26% of the respondents were able to correctly estimate the sum of 39 + 127. The small number of correct responses for this item could be due to uncertainty over how to round off a 3-digit numeral to the nearest ten.

I.C2 Subtraction of whole numbers. Student performance on subtraction of whole numbers was not as good as on addition of whole numbers; it was rated "marginal". Six of the seven items on this subtest involved calculating the difference between two whole numbers. Subtraction problems which did not require renaming and regrouping (78 - 53 and 876 - 542) were

the easiest for the respondents. Problems with a zero in the minuend, 90 - 37 and 507 - 62, were more difficult. Each of these items was answered correctly by only 54% of the respondents.

The majority of the errors made on these problems were attributable to a failure to rename and regroup. Subtracting 146 from 625 was the most difficult problem for the students. Less than 50% were able to calculate the correct difference. Students who did not obtain a correct answer either failed to rename or regroup or renamed and regrouped improperly. The remaining item on the subtraction subtest dealt with estimating. Only 49% of the students were able to correctly estimate the difference for 93 - 34.

I.D1 Multiplication of whole numbers. Performance on this subtest was viewed as being "satisfactory". Of the six items which dealt with the basic facts, three were answered correctly by more than 95% of the students, two were answered correctly by approximately 90%, and one, 9 × 4, was answered correctly by 83%. They also had some difficulty determining the missing factor for these items.

Eighty-three percent of the students identified zero as the missing factor in item 96, while 70% identified 9 as the missing factor in item 97.

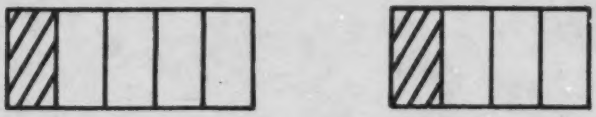
Each of the items dealing with multiplication of a two-digit number by a one-digit number was answered correctly by less than 67% of the students. The most difficult of these items, 25 × 6, was correctly answered by 53%. The difficulty with multiplication of a two-digit number could not be attributed to any single source of error.

I.D2 Division of whole numbers. Students were more successful with multiplication than they were with division. The interpretation panel viewed students' performance on division as being "marginal". Of the six items dealing with the basic division facts, four were answered correctly by less than 60% of the students. In addition, only 61% were able to identify 3 as the missing factor for 6 ÷ □ = 2. Some of the errors made on this subtest were due to students misinterpreting the division symbol as the addition symbol (the division symbol was not clear). In total 12% of the students added the numbers on three or more of the division items.

I.E Fractions and decimals. Of all the subtests dealing with number concepts, the results of this subtest were the least favorable and were rated "unsatisfactory". The items on the subtest dealt with identification of fractions given in pictorial form. While 72% of students were able to identify one-third of a set of three objects, only 29% of the respondents were able to identify one-third of a set of six objects. Students' difficulties with fraction concepts were not limited to reorganizing fractional parts of sets; only 64% of the respondents were able to answer the following item correctly

(27.) Which is $\frac{1}{4}$ shaded?

A) ☐ B) ☐



C) ☐ D) ☐

Approximately 15% chose alternative C which indicates that some students did not recognize that a whole must be divided into equivalent parts.

I.G Patterns. Performance on the patterns subtest was interpreted as being "marginal". Four of the items on the subtest were similar to the following:

(22.) Write the number which comes next.

7, 9, 11, 13, 15

Three of these four items were answered correctly by fewer than 54% of the students. The item causing the most difficulties involved the sequence: 1, 3, 6, 10, 15 This was the only sequence in which the difference between successive numbers was not constant. Only 18% of the respondents were able to answer the item correctly. Of the items which involved sequences with a constant difference between successive numbers, students had less difficulty with increasing sequences (7, 9, 11, 13, 15) than with decreasing sequences (40, 35, 30, 25, 20).

The remaining two items on the subtest dealt with continuing pictorial patterns such as the following:

(20.) Draw the shape that comes next.

△ △ □ △ △ □ △ △

Both of these items were answered correctly by more than 90% of the students.

I.H Applications. Subtest I.H comprised eight word problems which could be solved by the direct application of one or more of the four basic operations. Problems involving the operations of addition and multiplication caused fewer difficulties than the problems involving subtraction and division, but overall performance was rated "unsatisfactory".

Approximately 84% of the students were able to give the correct solution to the following addition problem:

(23.) There are 212 girls and 157 boys in Royal School. How many children are there altogether?

However, 38% of the respondents were able to solve the following division problem:

(78.) Stan has 40 apples and 5 boxes. He puts the same number of apples in each box. How many apples are in each box?

Problems involving the operation of multiplication were solved correctly by 60% or more of the respondents, while the problems involving the operation of subtraction were solved correctly by fewer than 56% of the respondents.

Students' difficulties with subtest I.H stemmed primarily from a failure to identify the operation needed for solving a given problem. Students had less difficulty identifying addition problems than problems involving the other three operations. Some pupils may be used to using concrete objects to solve problems.

II. Measurement

II.A Linear Measurement. Of the four subtests involving measurement concepts, only the results of this subtest were viewed as being "satisfactory". The subtest assessed six aspects of linear measurement: identifying objects approximately one metre in length; identifying the most appropriate unit of measure; estimating the length of a given object; measuring the length of a given line segment; converting metres to centimetres; and indicating the relationship between metres and centimetres. The percentage of students selecting the correct response was consistent for the two items dealing with the selection of the most appropriate unit of measurement (84%) and the two items on estimating the length of a given object (approximately 71%).

Some student confusion over the relationship between metres and centimetres was indicated by their responses to the following:

(34.) One metre is the same length as

- ☐ 10 cm (centimetres)
- ☐ 1 cm (centimetre)
- ☐ 100 cm (centimetres)

(54.) 100 centimetres is the same length as

- ☐ 100 m (metres)
- ☐ 1 m (metre)
- ☐ 10 m (metres)

Seventy-two percent of students answered item 34 correctly while 55% were able to answer item 54 correctly. The confusion over the relationship between metres and centimetres was also reflected in the responses to the unit conversion items:

(53.) 8 metres is the same length as

- ☐ 8 cm (centimetres)
- ☐ 80 cm (centimetres)
- ☐ 800 cm (centimetres)

(55.) 500 centimetres is the same length as

- ☐ 1 m (metre)
- ☐ 5 m (metres)
- ☐ 500 m (metres)

Approximately 57% of students answered item 53 correctly while 70% answered item 55 correctly.

Students had some difficulties with the concept of a metre. While 74% were able to identify a baseball bat as being approximately one metre in length, 65% were able to indicate that a teacher's desk is approximately one metre high.

The item which caused the most difficulty was:

(69.) Find the length of the line segment to the nearest centimetre (cm).

Approximately 54% of the students answered the above item correctly, whereas 19% failed to round off the measure to 8 and 20% recorded a measure that was either greater than 9 or less than 7.

II.BC Area, volume, and capacity. Four items dealing with the concepts of capacity and area made up this subtest. Performance was rated as "unsatisfactory" with the following item causing the most difficulty:

(41.) Find the area. Each ☐ is one square centimetre (cm^2).

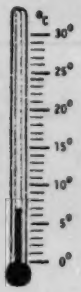
Only 30% of the students were able to indicate that the area of the above figure was 8 cm^2. Approximately 33% either ignored the half units or counted each half unit as one unit.

The results for the items dealing with capacity suggest that students are not very familiar with millilitres and litres. About 50% were able to indicate that the millilitre was the most appropriate unit for measuring the capacity of a cup and 61% were able to indicate that the litre was the most appropriate unit for measuring the capacity of a bathtub.

II.EFG Money, time and temperature. Performance on this subtest was also viewed as being "unsatisfactory". The results indicate that the students know the value of different coins and know the sequence of days in a week. The results also indicate that students are more familiar with reading a clock in terms of minutes past the hour than with minutes to the hour. Seventy-five percent of the respondents were able to identify a clock face which showed 35 minutes past two, while only 52% of the respondents were able to identify a clock face which showed 25 minutes to 11.

The items dealing with temperature caused the most difficulties:

(61.) Write the temperature.



Approximately 15% of the students indicated that the temperature shown on the above thermometer was 7°C. However 53% of the respondents gave the correct reading (7), but failed to record the units (°C). The results suggest that students' difficulties lie more with recording a measurement properly than with identifying the number reading on the thermometer.

II.H Application. All four of the items on this subtest were answered correctly by less than 40% of the respondents resulting in an "unsatisfactory" rating. Of the items dealing with application of linear measurement, the one that caused the most difficulty is indicated below; only 18% of students were able to give the correct solution.

(38.) Sue is 134 centimetres tall. Her sister is 158 centimetres tall. How much taller is Sue's sister?

Of the items dealing with money, the following caused the most difficulty, with 27% of students answering correctly.

(56.) John bought 3 stamps. Each stamp cost 17¢. How much did he spend altogether?

Again many of the students' difficulties with these items were due to a failure to record the units of measure; 33% or more of the errors on the linear measurement problems were due to a failure to record the answers properly, while 16% or more of the errors on the money problems were due to improper recording techniques.

Like subtest I.H, the results also indicate that students have fewer difficulties with addition problems than subtraction problems.

III. Geometry

Performance on the geometry subtest was viewed as "satisfactory". The results suggest that students have a basic understanding of the following concepts: face (side of a 3-D object), straight edge, curved edge, angle, and parallelism. Of these concepts students have the most difficulty with the concept of an angle.

The results also suggest that students have a better understanding of perimeter than they do of area. Both items involving the calculation of the perimeter of a region were answered correctly by approximately 69% of the respondents while both items on the calculation of area were answered correctly by fewer than 58% of the respondents (see subtest II.BC).

IV. Graphing

Performance on the graphing subtest was "very satisfactory". The three items on this subtest dealt with interpretation of bar graphs. Slightly more than 60% of the students answered all three questions correctly, while 24% of the students were able to answer two of the three questions correctly. Again, students had more difficulties with the item involving subtraction than they did with the item involving addition.

Results by Cognitive Level

The interpretation panels were also asked to rate performance across topic areas in each of the three designated cognitive levels. These performances and the corresponding ratings are shown in Table III-2.

Table III-2

Grade 3: Results by Cognitive Level

Cognitive Level	No. of Items	Average Percentage Correct	Interpretation Panel Rating
Knowledge and computation	41	70	Satisfactory
Comprehension	32	68	Satisfactory
Application	27	60	Marginal

These ratings across cognitive levels appear to confirm the subtest ratings, with application level problems causing greater difficulties.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

1. In computations with whole numbers addition and multiplication were well handled, while both subtraction and division were weak areas. In subtraction, problems involving renaming and regrouping seemed to cause the difficulties.

RECOMMENDATION: That subtraction and division receive appropriate attention by teachers and that they be taught as inverse operations of addition and multiplication respectively.

2. Problems on the conceptual understanding of fractions were not well handled.

3. Applications, i.e., word problems, caused difficulties. Where the type of error was identifiable, it was most often in selecting the incorrect operation.

RECOMMENDATION: That more emphasis be placed on applications. In some cases this may mean more time, but alternate approaches should be considered, e.g., embedding applications in the review.

4. Interpretations of bar graphs was well done.

5. The area of measurement indicated both real strengths and real weaknesses. Linear measurement was well done, calculating areas and application problems were difficult. On the other hand, nonnumerical geometry items fared well. There is clearly overlap between the categories of geometry and measurement and a discussion of the achievement trends in these areas may be found in Chapter VII. Both the weak and the strong areas at the grade three level are clearly indicated in Table III-1.

RECOMMENDATION: That more emphasis be placed on measurement, particularly area and volume and on the development of geometric concepts.

6. Performance in the area of pattern recognition was judged as only marginal.

RECOMMENDATION: That more emphasis be placed on patterns, i.e., discussions on the relationships between numbers.

CHAPTER IV

GRADE 6 RESULTS

The grade 6 test consisted of 98 items and assessed four broad areas: Number Systems, Operations and Properties; Measurement; Geometry; and Graphing. These areas were further divided into fourteen discrete subtests. Two additional subtests were made up of one- and two-step word problems from several topic areas. All of the skills tested are found in the Grade 6 section of the provincial curriculum guide.

A total of 1401 grade 6 students made up the provincial sample. This is approximately 92% of the 10% sample designated for the provincial survey.

ACHIEVEMENT RESULTS

The actual results together with the ratings of the Interpretation Panels are presented in Table IV-1. Each of the subtests are discussed in turn. For details of student performance on test items refer to Volume II of the Preliminary Report.

The Interpretation Panel ratings shown in Tables IV-1 and IV-2 are based on a five-category scale: Strength, Very Satisfactory, Satisfactory, Marginal, and Unsatisfactory. A description of these categories is given in Chapter II (p.13).

Table IV-1

Grade 6: Results on Subtests

	Subtest Within Topic Area	No. of Items	Average Percent Correct	Interpretation Panel Rating
I.	Number Systems, Operations, and Properties			
	I.ACD Place Value, Regrouping, and Rounding Off	8	65	Marginal
	I.E Inequalities	4	86	Strength
	I.F Patterns	1	42	*
	I.GH Factors and Prime and Composite Numbers	5	46	Unsatisfactory
	I.J Properties	5	87	Strength
	I.KL Addition and Subtraction of Whole Numbers	11	83	Strength
	I.M Multiplication of Whole Numbers	9	77	Very Satisfactory
	I.N Division of Whole Numbers	9	65	Satisfactory
	I.OV Fractions and Percent	8	61	Satisfactory
	I.PQ Operations with Fractions	10	57	Marginal
	I.STU Operations with Decimals	9	57	Marginal
II.	Measurement	9	46	Unsatisfactory
III.	Geometry	6	50	Marginal
IV.	Graphing	4	62	Marginal
I.W1	Word Problems - One Step	6	72	Very Satisfactory
I.W2	Word Problems - Two Step	6	60	Satisfactory

*Insufficient items for Interpretation Panel rating.

I. Number Systems, Operations, and Properties

I.ACD Place value, regrouping, and rounding off. The Interpretation Panel rated performance on this section as "marginal". The eight items dealt with place value, regrouping, and rounding. Relating expanded notation to the suitable numeral offered students little difficulty. Also, renaming a given number was well done.

Identifying the place value of the digit 3 in the numeral 534 896 201 was correctly answered by 70% of the students. Rounding off a numeral to the nearest thousand was correctly answered by 58% and rounding off to the nearest hundredth dropped to 42% correct. The place value items with decimal fractions were more difficult; when students were asked to identify how 524.013 would be written in words, 43% were able to identify the correct answer.

I.E Inequalities. The subtest on Inequalities has four items, all of which test the ordering of whole numbers. Elementary students need to use the inequality symbols frequently, otherwise they will tend to confuse them. This subtest was rated as a "strength", with an average percent correct of 86%.

I.F Patterns. The study of number patterns is an important topic although only one item of this type was used in the test. The question was:

(13.) What is the next numeral in the sequence 1, 4, 9, 16, ____?

A) 21 * C) 25
B) 23 D) 36

The correct answer was selected by 42% of the students. Overall performance on this subtest could not be rated since there were too few items for the Interpretation Panel to make an accurate judgement.

I.GH Factors and prime and composite numbers. The meaning of "prime" appeared to be not well understood and the subtest results were rated "unsatisfactory" by the Panel. The five items in the section covered prime factors, common factors, greatest common factor, and least common multiple. Only 32% of students were able to select the prime factors of 36 and 28% could select the prime factors of 12. The common factors of 16 and 20 were found by 55% of the students, but the least common multiple of 6 and 14 was correctly identified by 44%.

I.J Properties. With an average percentage correct of 87% this area was rated as a "strength". There were five items in this subtest, one on each of the following: commutative property of addition, associative property of addition, associative property of multiplication, the additive identity, and the multiplicative identity. Four or more of these items were correctly answered by over 80% of the students, indicating a high level of competence.

I.KL Addition and subtraction of whole numbers. Out of a possible score of 11, over 72% of the student sample scored 9 or better for an overall mean correct of 83%. Student performance on this subtest was rated as a "strength". With the possible exception of one item, word problems in this area were also well done.

I.M. Multiplication of whole numbers. The subtest on multiplication of whole numbers contained nine questions, two of which were word problems. Overall performance on this topic was rated "very satisfactory". A few possible weaknesses do exist, however. For example,

38. 0 x 374 =

* A) 0
B) 374
C) 3740
D) 3074

This item was correctly answered by 76%, but 21% selected response B. This emphasizes the importance and need of frequent review of basic concepts.

To underline this idea, in the question:

37. 745 x 100 =

A) 745 000
* B) 74 500
C) 7450
D) 745

approximately 70% selected the correct response and 19% selected response A. Questions involving multiples of 10, 100, and 1000 are important for elementary students to master because, beyond the importance of this skill in the multiplication algorithm, it is necessary for mastery of the division algorithm.

I.N Division of whole numbers. Overall student performance on division of whole numbers was rated as "satisfactory" with an average correct of 65%. Certain weaknesses were identifiable as a result of student choices in answering the test items. For example, in the following question:

45. 0 ÷ 6 =

* A) 0
B) 1
C) 6
D) cannot be done

approximately 47% answered correctly and 40% claimed that the question could not be done (D).

When division was expressed as an inverse operation, the students experienced difficulty. In the following question 64% answered correctly.

47. The solution for 38 x □ = 1786 is

A) 37
B) 42
C) 46
* D) 47

Perhaps some students attempted to use the multiplication algorithm to find the solution.

Another source of difficulty in division occurred when there was a zero in the quotient. For example, in

(51.) Divide: $4\overline{)424}$

A) 16
B) 101
* C) 106
D) 160

64% selected 106, the correct response, but 21% selected 16. Those selecting 16 could not have used the skill of estimation to check the reasonableness of their answer.

I.OV Fractions and percent. This subtest assessed skill in dealing with equivalent fractions, ordering fractions, renaming a mixed number as an improper fraction, and writing a percent as a fraction. The results were rated as "satisfactory" for the total subtest, although considerable difficulty occurred on an item that required students to compare two fractions.

(58.) Which of the following is true?

A) $\frac{1}{6} > \frac{1}{3}$
B) $\frac{2}{5} < \frac{3}{10}$
C) $\frac{1}{2} > \frac{5}{8}$
* D) $\frac{3}{4} < \frac{7}{8}$

In this question 36% of students selected the correct response, while 39% chose answer C. Inequality signs add to the difficulty of this item, but it would seem that many students have no visual image of these fractions which would allow them to make a comparison. Moreover, many students do not seem to relate the comparison (or ordering) of fractions to equivalent fractions.

A question on the ordering of a set of fractions with like denominators was correctly done by 61%, and most of the rest of the students (23%) apparently misread the instructions and selected the reverse order of that requested.

I.PQR Operations with fractions. Performance on the ten items in this subtest rated "marginal". Addition and subtraction of fractions with like denominators was well done, but students encountered much more difficulty in problems where unlike denominators were used. For example, in the following question,

(66.) Subtract: $\frac{5}{8} - \frac{1}{4} =$

*A) $\frac{3}{8}$
B) $\frac{4}{4}$
C) $\frac{1}{8}$
D) $\frac{4}{8}$

54% of the students selected the correct answer (A), but 25% chose $\frac{4}{4}$, indicating that they had subtracted numerators and also subtracted denominators.

Multiplication of a fraction by a whole number was correctly answered by 43% of the students and multiplication of a whole number by a mixed number was answered correctly by only 38%.

I.STU Operations with decimals. The skills tested in this section were: matching a decimal numeral with its written expression, expanded notation, and the four basic operations with decimals. The overall performance of 57% correct was rated by the Panel as "marginal".

Many of the problems that students encountered in this subtest were related to place value and the placement of the decimal point in the result of a calculation. This is illustrated by answers to the item:

(74.) Add:
$$\begin{array}{r} 0.6 \\ 0.8 \\ +\ 0.9 \end{array}$$

A) 0.023
B) 0.23
* C) 2.3
D) 23

The percentage of correct responses was 49, but 40% chose (B) as the correct sum. A similar lack of understanding was manifested in a subtraction item.

The level of performance was lower when the operation was multiplication. For example, 0.01 × 2300 was answered correctly by only 20% of students.

II. Measurement

The subtest on measurement contained nine items with a mean score of 46%; this was rated by the Panel as "unsatisfactory". Three of the items related to perimeter, area, and the calendar; the others related to the understanding of the metric (SI) system of measurement. Items requiring students to find the perimeter and area of a rectangle and a square, respectively, had a percentage correct score near the mean score, while an item which asked, "One month is about what fraction of a year?" was answered correctly by 60% of the students. A particularly difficult metric item was the following:

(78.) In the metric system of measurement, what does the prefix "centi" mean?

A) 100 times the unit of measure
B) 10 times the unit of measure
C) 0.1 of the unit of measure
* D) 0.01 of the unit of measure
E) 0.001 of the unit of measure

Only 14% answered the above question correctly. But 81% estimated correctly the length of a crayon as 10 centimetres. Conversions from one unit to another in the metric system posed

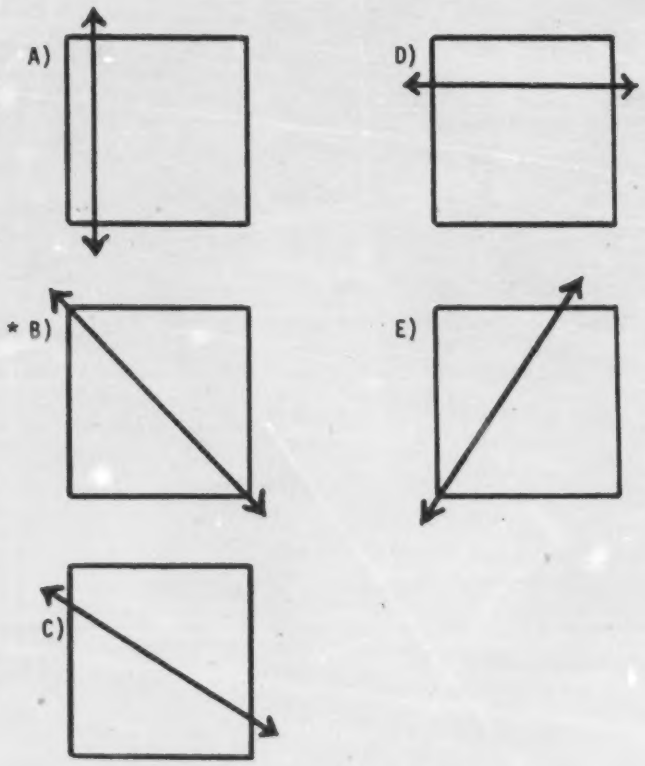
considerable difficulty. The overall low achievement on this section suggests that students are insufficiently exposed to the metric system.

On another item, only 64% correctly read a Celsius thermometer. This difficulty is likely caused by more than unfamiliarity with the metric system.

III. Geometry

Like Measurement, the results on Geometry were judged "unsatisfactory" by the Panel. Of the six geometry items, only the following was answered correctly by more than 60% of the students.

92. Which figure shows a line of symmetry for a square?



The responses to items involving motion geometry were unsatisfactory. A slide image of a figure was correctly identified by 56% of the students, and a flip image by 48%.

Only 36% identified an obtuse angle and only 49% correctly identified the diameter of a circle. This poor performance strongly suggests that students have had insufficient exposure to geometry and may be unfamiliar with the terminology.

IV. Graphing

Results on the graph interpretation items were rated "marginal". There were two items on a bar graph and two on a line graph. Results on one particular item tended to pull down the overall mean (62%) -- this item had as the correct response "None of the above". Of the students 44% selected this response, while 31% selected the "closest" answer.

Word Problems

The two subtests delineated in this section contained items from several of the subtests discussed above.

I.W1 Word problems - one step. There were six one-step word problems on which students achieved a mean correct of 72%. This was rated as "very satisfactory" by the Interpretation Panel.

I.W2 Word problems - two step. This subtest also contained six items. The mean percent correct was 62% and the performance was rated "satisfactory". A sample problem from this test is

(70.) Mario bought a pizza to treat his friends. One-eighth of the pizza has 185 calories. How many calories are there in $\frac{1}{4}$ of a pizza?

A) $92\frac{1}{2}$ calories
C) 555 calories
* B) 370 calories
D) 1480 calories

The percent of correct answers was 46, but 35% chose (A) $92\frac{1}{2}$ calories. The relationship between the fractions $\frac{1}{8}$ and $\frac{1}{4}$ is apparently not understood by a substantial number of students.

Results by Cognitive Level

In addition to rating performance in each of the topic area subtests, the Interpretation Panel rated performance in each of the following cognitive levels: Knowledge and Computation, Comprehension, and Application. These ratings are given in Table IV-2.

Table IV-2
Grade 6: Results by Cognitive Level

Cognitive Level	No. of Items	Average Percentage Correct	Interpretation Panel Rating
Knowledge and Computation	37	65.4	Satisfactory
Comprehension	46	62.8	Marginal
Application	15	65.2	Satisfactory

There is no significant variation among the percentages correct at each of the three cognitive levels.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

1. Place value both in whole numbers and decimal fractions is not well understood. Furthermore, students have difficulty in rounding off numbers and estimating results prior to a calculation.

RECOMMENDATION: That place value be reviewed at each grade level and that students be given practice in estimating results.

2. Prime numbers and prime factorization appears not to be well understood.

3. Addition and subtraction of whole numbers was an area of strength.

4. Multiplication and division were handled satisfactorily with few exceptions. Multiplication by 0 and division by 0 were not adequately understood and students lacked proficiency in the division algorithm when there were zeros in the quotient.

5. Students had difficulty ordering pairs of fractions with different denominators.

6. Students did not show proficiency in working with equivalent fractions, and in particular, have not mastered addition and subtraction of fractions with unlike denominators.

7. Multiplication of fractions was poorly done.

RECOMMENDATION: That basic concepts and skills from earlier grade levels be part of ongoing review, in part by embedding them in a problem solving context.

8. While students were able to estimate the length of a crayon in centimetres, they were unable to make conversions of units within the metric system or to calculate the area or perimeter of a rectangle.

9. Geometric terminology was poorly understood, although some understanding of symmetry and transformations was demonstrated. (The reader is also referred to the section on geometry in Chapter VII.)

RECOMMENDATION: That the topics of geometry and measurement receive more attention in the classroom and in professional development.

10. A further general concern wherever lack of understanding is prevalent is the extent to which manipulative materials are being used in the classroom.

RECOMMENDATION: That school divisions be urged to supply, and teachers to use, more supporting manipulative and reference materials in elementary mathematics.

CHAPTER V

GRADE 9 RESULTS

The grade 9 test consisted of 81 items in fourteen subtests over five broad areas: Number Systems, Operations, and Properties; Measurement; Geometry; Algebra; and Graphing and Statistics. All of the skills tested are found in the Grade 9 section of the provincial curriculum guide.

A total of 1298 students, 656 males and 618 females, comprised the provincial sample. This is approximately 89% of the 10% sample designated for the provincial survey.

ACHIEVEMENT RESULTS

The actual results together with the ratings of the Interpretation Panel are shown in Table V-1. Each of the subtests is discussed in turn. For more detailed information on test items refer to Volume III of the Preliminary Report.

The Interpretation Panel ratings shown in Tables V-1 and V-2 are based on a five-category scale: Strength, Very Satisfactory, Satisfactory, Marginal, and Unsatisfactory. For a more complete description of these categories see Chapter II (p. 13).

Table V-1

Grade 9: Results for Subtests

	Subtest Within Topic Area	No. of Items	Average Percentage Correct	Interpretation Panel Rating
I.	Number Systems, Operations and Properties			
	I.A.1 Basic Operations	16	57	Marginal
	I.A.2 Order and Word Problems	4	63	Satisfactory
	I.A.3 Square Root	5	47	Marginal
II.	Measurement	3	53	Satisfactory
III.	Geometry			
	III.A Basic Constructions	2	49	Unsatisfactory
	III.B Angles and Parallel Lines	4	44	Unsatisfactory
IV.	Algebra			
	IV.A.1 Terminology	3	57	Unsatisfactory
	IV.A.2 Exponents	5	40	Unsatisfactory
	IV.A.3 Simplifications	11	57	Satisfactory
	IV.A.4 Substitutions	5	62	Satisfactory
	IV.B Equations	14	53	Unsatisfactory
	IV.C Word Problems	4	52	Marginally Satisfactory
V.	Graphing and Statistics			
	V.A Arithmetic Mean	2	71	Satisfactory
	V.B Graphs	3	55	Marginal

I. Number Systems, Operations and Properties

I.A.1 Basic operations. This subtest dealt with the basic operations in the sets of whole numbers, integers, and rational numbers and included problems on absolute value. Performance was rated by the Interpretation Panel as "marginal", but specific areas of weakness are evident. Operations involving decimal fractions show poor understanding of place value and a lack of appreciation of the magnitude of the numbers. This difficulty is illustrated in the following problem, which was answered correctly by 50% of the students.

(3.) The quotient of $70 \div 0.001$ is

A) 0.07
B) 7
C) 700
D) 7000
* E) 70 000

In item 8 approximately 40% of students responded correctly. Of particular significance is the fact that 30% selected -0.5 as the correct answer. This indicates a double area of confusion: confusion concerning operations on integers and possible confusion concerning the meaning of the term "product".

(8.) The product of -0.3 and -0.2 is

A) -0.06
B) -0.6
C) -0.5
* D) 0.06
E) 0.6

I.A.2 Order and word problems. This subtest received a "satisfactory" rating by the Interpretation Panel. Of the students, 51% correctly answered an item on order of operations. A word problem on percentage, representing an area of everyday applications, was done correctly by 43%.

(55.) A salesman received 20% of the retail value of his sales as commission. What must his total retail sales be if he is to earn a commission of $60?

A) $80
B) $1200
C) $120
D) $3000
* E) $300

I.A.3 Square root. Performance on items relating to irrational numbers, square roots, and problems involving the application of the Pythagorean theorem was rated as "marginal". Only 32% of the students were able to select the irrational number from a given set. Students scored 39% and 31% correct on two problems requiring application of the Pythagorean theorem.

II. Measurement

This topic area contained one subtest and the results were rated "satisfactory" by the Interpretation Panel. The average percent correct in this section was 53%.

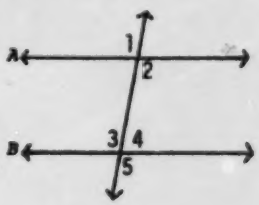
III. Geometry

III.A Basic constructions. Student results on basic geometric constructions were rated as "unsatisfactory". The two constructions required were: to bisect a given angle, and to construct a triangle congruent to a given triangle. Three marks were allotted to each question: a score of 6 represented a perfect score. A score of 6 was attained by 21% of students, a score of 3 by 20%, and a score of 0 by 30%.

III.B Angles and parallel lines. The average percent correct of 44% on problems involving angles and parallel lines was rated as "unsatisfactory" by the Interpretation Panel. The simpler relationships were not understood, for example:

(50.) If line A and line B are parallel, and $m\angle 2 = 130^0$, then $m\angle 4$ is

A) 40^0
* B) 50^0
C) 60^0
D) 65^0
E) 70^0



Geometry is a core topic in the mathematics curriculum. The examination was held May 13, and perhaps some students had not yet covered the topic by that date. However, as a core topic this material should be covered earlier.

IV. Algebra

IV.A.1 Terminology. The section on terminology was rated "unsatisfactory". Students appeared to be unfamiliar with terms such as "exponent", "base", "numerical coefficient", and "monomial".

IV.A.2 Exponents. This subtest was rated "unsatisfactory" by the Interpretation Panel. The test includes changing whole numbers into exponential form and vice versa, writing large and small numbers in scientific notation, and operations with exponents.

Students had difficulty with straightforward problems such as the following (59% obtained the correct answer).

(21.) 64 is equivalent to

A) 4^4
B) 2^5
* C) 2^6
D) 8^8
E) 32^2

IV.A.3 Simplifications. The average percent correct on this subtest, 57%, was rated as "satisfactory" by the panel. Students show reasonable competence in this area; several items were obtained correctly by 70% of students.

One area of weakness was the application of the distributive property to multiply a monomial by a binomial:

(34.) A simpler form of $2a(3 - 4b)$ is

A) $6a - 4b$
B) $5a - 4b$
C) $5a - 8b$
D) $6a - 6b$
* E) $6a - 8ab$

Response A was selected by 23% of the students.

IV.A.4 Substitutions. This subtest assessed the ability of students to evaluate open expressions in one or two variables using substitution. The mean percent correct of 62% was rated "satisfactory" by the Interpretation Panel. Evaluations requiring the substitution of a negative number presented greater difficulty.

IV.B Equations. The ability to solve algebraic equations was viewed as an important topic and 14 items were included. Student performance was rated as "unsatisfactory". The average percent correct was 53%. The curriculum guide for grade 9 lists the specific types of equations that should be mastered at this level. The test included each of the types listed in the curriculum.

In a simple equation, such as $7x = 63$, over 85% of students were able to find the correct solution, but as soon as more complexity was introduced performance dropped. There seemed to be some basic confusion about the meaning of equality, and how to maintain equality as like terms are gathered (equivalent equations); 35% of students answered correctly this item:

(63.) If $12 + 7x = 11 - 2x$, then $x =$

A) -1
B) 1
C) $\frac{23}{9}$
D) $-\frac{1}{5}$
* E) $-\frac{1}{9}$

On an optional topic item, however, the students did well (68%):

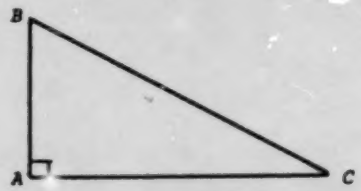
(72.) If $x^2 + 15 = 64$, a value of x is

A) 79
B) 49
C) 8
* D) 7
E) 6

IV.C Word problems. Average performance of 52% correct on this subtest was rated as "marginal". Algebraic problems were answered at a satisfactory level, while problems which required a geometric knowledge of perimeter and area were unsatisfactory. For example,

(79.) One leg of a right triangle is twice as long as the other leg. The area of the triangle is 49 cm^2. The length $\overline{AC}$ is

A) 7 cm
* B) 14 cm
C) 21 cm
D) 28 cm



Responses A and C were chosen by a total of 47% of the students and the correct solution by only 33%.

V. Graphing and Statistics

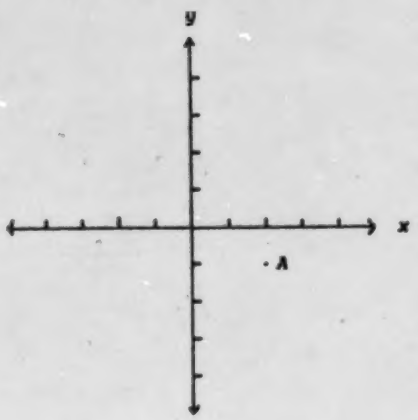
V.A Arithmetic mean. Results for this two-item subtest were rated by the Panel as "satisfactory". The average percent correct was 71%.

V.B Graphs. This section was rated as "marginal" with an average percent correct of 55%. Graphing is a topic introduced in grades 7 and 8, and should be reviewed in the problem solving sections in grade 9.

The question that seemed to offer the greatest difficulty required the student to identify the coordinates of a point located in the fourth quadrant; 40% of students could do this correctly:

(75.) Point A has the coordinates

A) (2, 1)
B) (1, 2)
C) (-1, 2)
D) (-2, -1)
* E) (2, -1)



An item on the interpretation of a circle graph involving percents was answered correctly by 42%. On the other hand, 82% were able to correctly respond to a question requiring the interpretation of a bar graph.

Results by Cognitive Level

In addition to rating student performance on each subtest, the Interpretation Panel was asked to rate student performance on the three cognitive levels: knowledge and computation, comprehension, and application. The performance in these three levels is given in Table V-2.

Table V-2

Grade 9: Results by Cognitive Level

Cognitive Level	No. of Items	Average Percentage Correct	Interpretation Panel Rating
Knowledge and Computation	25	58.8	Marginal-Satisfactory
Comprehension	*46	52.0	Marginal-Satisfactory
Application	14	52.0	Satisfactory

*Each geometric construction was alloted a score of 3 marks, resulting in a heavier weighting in this section.

At the knowledge and computation level, students have difficulty with terminology. Computational skills are satisfactory.

Difficulties at the comprehension level are mainly due to poor grasp of terminology. Students seem exposed to general methods, but have difficulty with specific topics such as absolute value, scientific notation, parallel lines, and the Pythagorean relation.

At the application level, students cannot apply specific methods because they are not well understood. More class time should be spent in these areas.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

1. Within the general area of basic operations, absolute value was clearly not well understood.

2. The subtest on square roots, including applications of the Pythagorean Theorem, was poorly handled.

RECOMMENDATION: That students be given more opportunities to do practical problems involving the Pythagorean relation.

3. With one exception, problems on finding the area and perimeter of a rectangular region were satisfactorily done.

4. Little understanding of geometric construction or of angles and parallel lines was demonstrated. (The reader is also referred to the section on Geometry and Measurement in Chapter VII.)

RECOMMENDATION: The geometric concepts be given greater emphasis.

5. In general, students have not attained a satisfactory level of proficiency in algebra. The weakest areas are exponents, equations, and terminology. Students should be proficient in solving all types of equations presented in the Curriculum Guide (p. 151, Note 2).

RECOMMENDATION: That the 1979 Curriculum Guide be followed by teachers and that the core topics given in the Guide be given priority over option topics.

6. A general concern in regard to overall grade 9 performance is that knowledge and mastery of the previous grade level content such as geometry, graphs, and percentage is not adequate for students at the grade 9 level.

RECOMMENDATION: That basic concepts and skills from earlier grade levels be part of ongoing review, in part by embedding them in a problem solving context.

CHAPTER VI

GRADE 12 RESULTS

There are three tests at the grade 12 level: a 12-General test including practical mathematics, a 12 - 300 test covering the content of Mathematics 300, and a 12 - 300 test covering the content of Mathematics 301. All students at the grade 12 level were sampled for the 12-General test and students in the full-year or in the second semester of Mathematics 300 and 301 also wrote the appropriate test, 12 - 300 or 12 - 301.

The items of the 12-General test fit the overall topic area designations used at the other grade levels. The skills tested have their basis in the work of earlier grade levels, primarily grades 7-9. The other two grade 12 tests, however, are course specific and each has its own list of topic areas based on the respective curriculum guides. The discussion of results and their interpretation will thus be divided into three parts:

1. 12-General Results
   a) Students with no grade 12 mathematics
   b) Students with Mathematics 300
   c) Students with Mathematics 301
2. Mathematics 300 Results
3. Mathematics 301 Results

In each of these parts a summary and discussion of results will be provided by topic area and, where numbers of items permit, by cognitive level. Results on the 12-General test will be discussed separately for the three student populations.

The Interpretation Panel ratings shown in the tables are based upon a five category scale: Strength, Very Satisfactory, Satisfactory, Marginal, and Unsatisfactory. A description of these categories is given in Chapter II (p. 13).

THE 12-GENERAL TEST

The data for the 12-General test are separated for three groups of students: the number of tests scored for each group are described below:

Group	Number of 12-General Tests Scored		
	Females	Males	Combined
Students with no grade 12 Mathematics	127	150	285
Students with Mathematics 300	297	318	626
Students with Mathematics 301	246	207	466

The numbers of students differ from those for the 12 - 300 and 12 - 301 tests since students are included here who had received credit for Mathematics 300 or 301 in a previous semester or year.

The topic areas and cognitive levels were identified in Chapter II and are identical to those used at earlier grade levels.

12-General Results: Students with No Grade 12 Mathematics

The actual results together with the ratings of the interpretation panels are shown in Table VI-1. Each of the subtests will be discussed in turn. For item detail the reader is referred to Volume IV of the Preliminary Report.

TABLE VI-1

12-General: Students with No Grade 12 Mathematics

Subtest Within Topic Area	No. of Items	Average Percent Correct	Interpretation Panel Rating
A. Number Systems & Operations			
A1. Basic Operations	9	55	unsatisfactory
A2. Ratios, and interrelationships among fractions, decimals and percents	6	62	marginal
B. Measurement	4	87	very satisfactory
C. Geometry	7	46	unsatisfactory
D. Algebraic Concepts	4	43	marginal
E. Graphs and Statistics	5	69	satisfactory
F. Consumer Applications	15	57	satisfactory

A. Number Systems and Operations

A1. Basic operations. Subtest A1 dealt with basic arithmetic operations in the set of rational numbers, including directed (signed) numbers, order of operations, and understanding of parentheses as grouping symbols. While perhaps marginally satisfactory in terms of social utility, the performance as a reflection of the curriculum was rated "unsatisfactory" by the Panel. Items causing the most difficulty were those with signed numbers, e.g., $\frac{18}{-3} = ?$, subtraction of fractions ($1\frac{2}{5} - \frac{1}{2} = ?$), and division of decimals ($\frac{-24}{.08} = ?$). The two division items were answered correctly by less than 40% of the students, the subtraction items by slightly less than 60%. In particular, the interpretation panels noted the weaknesses with signed numbers.

A2. Ratios and interrelationships among fractions, decimals and percents. This subtest yielded slightly better results and the performance was rated "marginal" by the interpretation panel. Students performed well in finding 20% of a number and in converting a percent (80%) to a fraction. When the percents themselves contained fractions the difficulty increased: writing 0.025 as a percent ($2\frac{1}{2}\%$). In summary, the basic straight forward percent and ratio items were handled satisfactorily, but any deviation to a more complicated problem resulted in difficulty.

B. Measurement

The student performance in the area of measurement was seen as a strong indication that

the basic everyday use of the metric system has been absorbed. These items required comprehension of basic units of volume, temperature, length, and weight. For all students, the item requiring an estimate (from among five choices) of the weight of a full grown man was the most difficult in the subtest. Nevertheless 78% got even this item correct.

C. Geometry

This was perhaps the most disappointing area on the test. Basic definitions of such terms as "perpendicular" and "diameter" are not well known, nor could students find the area of a triangle. Just over half were able to use the Pythagorean relation to find the length of the leg of a right triangle, but only 17% were able to find the area of a square given its perimeter. While the latter is not a simple, one-step problem, it is based upon knowledge of two basic definitions which appeared to be unfamiliar to students. Sixty-five percent were able to find the volume of a rectangular solid. In summary, a very weak area, seemingly due in large measure to lack of knowledge of basic definitions.

D. Algebraic Concepts

The area of algebraic concepts was considered less important than the other areas for students electing not to take grade 12 mathematics. Thus only four items were included. Students did relatively well on an item requiring evaluation of an algebraic expression given a value for the variable and in translating a verbal statement into an algebraic expression. A complex polynomial simplification item with two levels of parentheses caused real difficulties.

E. Graphs and Statistics

This subtest called for the interpretation of line graphs, circle graphs, and pictographs which presented data from everyday life. The results showed a "satisfactory" performance on straight forward graph interpretation as a consumer skill. Students clearly understood the structure of a circle graph, were able to complete a line graph. In addition to the graph interpretation items, 73% of the students were able to calculate the arithmetic mean of three numbers:

45. Last summer Todd earned $205, Charlotte earned $562, and Dale earned $400. What is the average (arithmetic mean) of their summer incomes?

*A) $389
B) $400
C) $583.50
D) $1167
E) None of the above

F. Consumer Applications

The largest subtest, and a major focus of the entire test, was consumer applications. The average percent correct for this section was 57%, considered by the interpretation panel to be "satisfactory" performance in view of the items presented. More than 70% of the students were able to correctly assess the sales tax on a new car in the following item:

27. The provincial sales tax is 5%. How much would the sales tax be on a new car that costs $6750.00?

A) $675.00
*B) $337.50
C) $67.50
D) $33.75
E) none of the above

An item on percentage discount at a clothing sale, clearly an everyday kind of problem, was correctly handled by 55% of the students:

28. Juno's Jean Joint has jeans on sale for 20% off the regular selling price. Jill is going to buy a pair that normally sells for $29.95. APPROXIMATELY how much will she have to pay?

A) $6.00
B) $23.00
*C) $24.00
D) $25.00
E) $35.00

Responses B or D were selected by over 35% of the students, who presumably either figured the percentage incorrectly or subtracted incorrectly, perhaps in the case of B, subtracting 6 from 29.

The most difficult consumer item of all (31% correct) was the following item on buying paint.

52. A litre of asphalt paint will cover about 6 m^2 of surface area. The paint is sold in cans of 5 litres only. How many cans are needed to paint a driveway 15 m long and 3 m wide?

A) 9
B) 8
C) 7
D) 1
*E) 2

This is a multistep problem which requires the student to: 1) find the area of the driveway, 2) find the area covered by a single can of paint, and 3) determine how many cans are required.

Students did well (over 70% correct) in calculating overtime pay in the following question:

56. Mrs. Schmidt works in a local factory for $6.00 per hour, plus time and one-half after 40 hours. Last week she worked 45 hours. How much did she earn?

A) $405
*B) $285
C) $270
D) $240

On a final item on calculating total (federal and provincial) tax payable on a specified taxable income, 53% of students were able to correctly enter the tax table and add the appropriate figures.

Results by Cognitive Level

The above discussion of results was based upon the percent correct in a series of topical subtests. In addition to this breakdown results were calculated by cognitive level across all topic subtests. These data are shown in Table VI-2.

TABLE VI-2

12-General: Students with No Grade 12 Mathematics
Results by Cognitive Level

Cognitive Level	No. of Items	Average Percent Correct	Interpretation Panel Rating
Knowledge and Computation	14	60	satisfactory
Comprehension	20	56	satisfactory
Application	16	58	satisfactory

Each of the levels was rated satisfactory by the interpretation panels, although not without some reservations. In particular, a large number of panel members found the Knowledge and Computation level performance only marginal. It should be borne in mind that the preceding discussion relates only to a sample of those students who have elected to discontinue the study of mathematics after grade 11.

12 General Results: Students with Mathematics 300

The results to be discussed in this section are for those students who had already completed, or were currently taking, Mathematics 300 at the time the assessment tests were administered in May 1981. This group of students has elected to take the academic mathematics program in grade 12 and a high proportion will go on to higher education. While their curriculum provides no explicit training in consumer skills, it is generally assumed that their academic training and ability will enable them to deal with such problems as they arise. The results for the Mathematics 300 group are presented in Table VI-3 (see p. 46).

A. Number Systems and Operations

A1. Basic operations. This subtest, dealing with basic rational number computation, was generally very well handled, as indicated by the 91% correct and the Panel's interpretation as a "strength". One low item, however, deserves mention:

17. $\frac{0}{5}$ =

*A) 0
B) Infinity
C) 5
D) cannot be done

Less than 80% correctly chose A, while 16% selected D. For students at the Mathematics 300 level this certainly shows a fundamental confusion surrounding the number zero and division.

TABLE VI-3

12-General: Students with Mathematics 300

Subtest Within Topic Area	No. of Items	Average Percent Correct	Interpretation Panel Rating
A. Number Systems & Operations			
A1. Basic Operations	9	91	strength
A2. Ratios, and interrelationships among fractions, decimals and percents	6	88	very satisfactory
B. Measurement	4	94	strength
C. Geometry	7	83	very satisfactory
D. Algebraic Concepts	4	81	satisfactory
E. Graphs and Statistics	5	89	very satisfactory
F. Consumer Applications	15	83	very satisfactory

A2. Ratios and interrelationships among fractions, decimals, and percents. The items in this subtest were generally answered correctly by about 90% of the students. Only one item fell significantly below this achievement level, namely:

20. Written as a percent, 0.025 =

A) 25%

*B) $2\frac{1}{2}$ %

C) $\frac{1}{4}$ %

D) $2\frac{1}{4}$ %

E) $1\frac{1}{4}$ %

Response C, $\frac{1}{4}$%, was selected by almost one-fifth of the students, suggesting difficulty in placing the decimal point in the conversion from decimal to percent.

B. Measurement

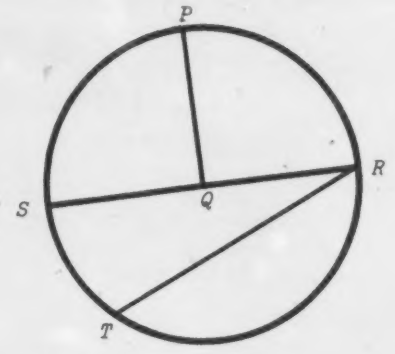
All items in the measurement subtest were correctly answered by 86% or more. Thus it is apparent that there is good basic understanding of everyday metric units for length, temperature, weight, and volume.

C. Geometry

Performance on the Geometry subtest was rated as "very satisfactory". Students showed understanding of basic terminology in such items as:

35. If Q is the center of the circle below, then $\overline{QS}$ is

A) a diameter
B) a circumference
C) a chord
*D) a radius
E) an arc



On the other hand, two items on area and perimeter caused real difficulties even for these students. The following item was answered correctly by only 57%:

39. A square has a perimeter of 20 cm. Its area in square centimetres is

A) 400
B) 80
C) 100
*D) 25
E) 20

This problem relies on basic notions and formulae studied in junior high school and used frequently since that time. Thus while overall performance in geometry was very good, the above difficulties should be noted.

D. Algebraic Concepts

The subtest on Algebraic Concepts was a short one, an indication of its low importance as a skill for those not requiring much mathematics. Thus it is by no means comprehensive, and those students completing the Mathematics 300 and Mathematics 301 tests had greater opportunity to display their algebraic skills on the course specific tests. Nevertheless, the panel felt the performance on these few algebraic items to be only "satisfactory". The item causing the most difficulty was one on simplifying an expression with parenthesis:

48. $5x - 2y - [2x - (3y + 4x)] =$

A) $7x - 5y$
B) $7x - y$
C) $-x - 5y$
D) $-x + y$
*E) $7x + y$

This item was answered correctly by only 55% of the students. On the other hand, students had good success in evaluating an algebraic expression and in translating a verbal expression into an

algebraic one.

E. Graphing and Statistics

The subtest on Graphs and Statistics was handled by this group with ease, only the pictograph item getting less than 88% correct. In this item students apparently failed to recognize the value of a partial symbol.

F. Consumer Applications

The overall performance on consumer application items was "very satisfactory". More than 95% of students could correctly determine a percent, as in the following problem:

26. In a school election with three candidates, Mike received 120 votes, Lawrence received 30 votes, and Lesley received 50 votes. What percent of the total vote did Mike receive?

A) 30
B) 40
*C) 60
D) 120

In fact, performance was well above the 75% level on most items, falling below this on only one, namely the asphalt paint problem given in the preceding discussion. Only 54% of Mathematics 300 students succeeded in correctly determining how many cans of paint were required. Despite an item such as this one, performance on the consumer items by this group was good even though such material is not an integral part of the 100-200-300 curriculum in mathematics.

Results by Cognitive Level

The Interpretation Panel was also asked to rate performance across topic areas in each of the three designated cognitive levels. These performances and the corresponding ratings are shown in Table VI-4.

TABLE VI-4
12-General: Students with Mathematics 300
Results by Cognitive Level

Cognitive Level	No. of Items	Average Percent Correct	Interpretation Panel Rating
Knowledge and Computation	14	91	strength
Comprehension	20	85	very satisfactory
Application	16	84	very satisfactory

These high interpretation ratings take into account the nature of the student sample and the particular sets of items. It can be concluded from both the cognitive level and the topic subtest results that the Mathematics 300 students did well on this general grade 12 test.

12-General Results: Students with Mathematics 301

This final set of results for the 12-General test is for those students who had already completed, or were in the process of completing, Mathematics 301 at the time the assessment tests were administered in May 1981. Mathematics 301 is an elective course for those who wish a grade 12 mathematics course, possibly, but not necessarily for entry into higher education in a field not requiring higher level mathematics. The results for the Mathematics 301 students on the 12-General test are shown in Table VI-5.

TABLE VI-5

12-General: Students with Mathematics 301

Subtest Within Topic Area	No. of Items	Average Percent Correct	Interpretation Panel Rating
A. Number Systems & Operations			
A1. Basic Operations	9	75	satisfactory
A2. Ratios, and interrelationships among fractions, decimals and percents	6	73	satisfactory
B. Measurement	4	90	strength
C. Geometry	7	59	unsatisfactory
D. Algebraic Concepts	4	61	marginal
E. Graphs and Statistics	5	77	very satisfactory
F. Consumer Applications	15	67	satisfactory

A. Number Systems and Operations

It can easily be seen in the table that performance on the test as a whole ran the gamut from "strength" to "unsatisfactory". In the two subtests on Number Systems and Operations the average proportion correct was about three-fourths. The Panel interpreted this results as "satisfactory" for this group of students who had a grade 12 mathematics course.

B. Measurement

The section on measurement was very well done with an average of 90% correct. This result was similar to that of the other grade 12 groups and thus appears to be a strong area for all grade 12 students.

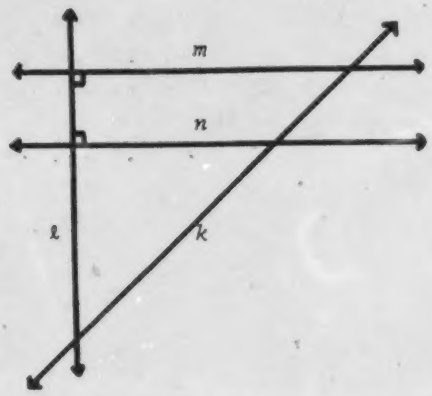
C. Geometry

In sharp contradistinction to the measurement results are those for geometry. As for the "non-grade 12 math" group, the results here were disappointing and "unsatisfactory". In the

following item:

36. From the diagram below, which of the following pairs of lines are perpendicular?

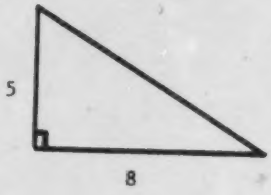
A) k and ℓ
B) m and n
C) k and m
D) k and n
*E) ℓ and n



Students were unable to distinguish parallel from perpendicular lines. Almost equal proportions (40+%) selected B and *E. This suggests that fundamental understanding of at least certain definitions is absent. An item on finding the area of a right triangle was even more difficult, with only 35% getting the correct answer.

38. Find the area of this right triangle.

*A) 20
B) 13
C) 40
D) 10
E) $\sqrt{89}$

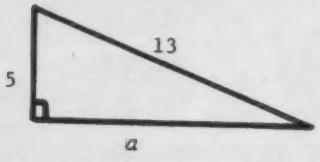


One-third selected response C. Would an item on finding the area of a rectangle have confused students or helped to clarify the previous problem for them?

Perhaps even more surprising was the result on the following items requiring application of the Pythagorean Theorem.

41. In the triangle below, find the length of the side marked a.

A) 65
B) 14
C) 18
D) $\sqrt{194}$
*E) 12



Only 62% could correctly apply this theorem initially learned in junior high school and used frequently since that time.

D. Algebraic Concepts

The subtest on algebraic concepts was rated "marginal" by the Interpretation Panel. The item causing most difficulty here was the same one that caused difficulty for the other groups of students. Most were unable to simplify an expression containing two levels of parentheses. They did, however, perform well on items requiring translation from a verbal to an algebraic statement and in evaluating an algebraic expression in one variable.

E. Graphs and Statistics

In the area of graphs and statistics overall performance was seen to be "very satisfactory". The pictograph was the most difficult item at 63% correct, but all other items were better, two of the five obtaining better than 82% correct.

F. Consumer Applications

Performance in the area of consumer applications was judged to be "satisfactory", with only one item getting below 55%. Thus the variation was not large and performance on most items, as well as on the entire subtest, could be declared satisfactory. The most difficult item here, as for other groups, involved finding the number of cans of asphalt paint necessary to paint a driveway.

Results by Cognitive Level

Interpretation Panel ratings by cognitive level are shown in Table VI-6. In view of the definitions of these categories and the students involved the ratings of very satisfactory, satisfactory, and satisfactory for Knowledge and Computation, Comprehension and Application, respectively, were seen as acceptable.

TABLE VI-6

12-General: Students with Mathematics 301

Results by Cognitive Level

Cognitive Level	No. of Items	Average Percent Correct	Interpretation Panel Rating
Knowledge and Computation	14	75	very satisfactory
Comprehension	20	69	satisfactory
Application	16	68	satisfactory

12-General: Summary

For each of the three population samples who took the 12-General test, results have been calculated separately. More importantly, the ratings by the Interpretation Panel have been made taking into account the distinctive nature and background of each of the three groups. A summary of these ratings is given in Table VI-7.

TABLE VI-7

12-General: Summary of Interpretation Panel Ratings

Subtest Within Topic Area	Interpretation Panel Ratings		
	No Grade 12 Mathematics	Mathematics 301	Mathematics 300
A. Number Systems & Operations			
A1. Basic Operations	Unsatisfactory	Satisfactory	Strength
A2. Ratios, and inter-relationships among fractions, decimals and percents	Marginal	Satisfactory	Very Satisfactory
B. Measurement	Very Satisfactory	Strength	Strength
C. Geometry	Unsatisfactory	Unsatisfactory	Very Satisfactory
D. Algebraic Concepts	Marginal	Marginal	Satisfactory
E. Graphs and Statistics	Satisfactory	Very Satisfactory	Very Satisfactory
F. Consumer Applications	Satisfactory	Satisfactory	Very Satisfactory

In addition to assessing performance on subtests for particular groups we are able with this data to examine trends across groups. Measurement, for example, showed excellent results overall, indicating good knowledge about fundamental metric units. Number Systems and Operations, on the other hand, showed markedly better performance by the groups with more mathematics experience, even taking that experience into account. Geometry was handled in an unsatisfactory manner except by the Mathematics 300 group. The small number of Algebraic Concepts items were marginally well handled by students with Mathematics 301 and with no grade 12 math, but only slightly better by those with Mathematics 300. Thus two basic areas of geometry and algebraic concepts appeared to be weak.

The two most consumer oriented subtests, namely Graphs and Statistics and Consumer Applications, were well done, with the results for all groups rated satisfactory or better. This suggests that these important skills are being learned, even by those in programs which do not emphasize consumer topics.

Conclusions and recommendations are discussed at the end of the chapter.

MATHEMATICS 300 RESULTS

The actual results together with the interpretation panel ratings are shown in Table VI-8. Each of the subtests will be discussed in turn. For item detail the reader is referred to Volume IV of the Preliminary Report.

TABLE VI-8

Mathematics 300: Results on Subtests

Subtest Within Topic Area	No. of Items	Average Percent Correct	Interpretation Panel Rating
A. Relations and Functions	9	54	Marginal
B. Exponential and Logarithmic Functions	6	51	Satisfactory
C. Circular Functions	6	50	Marginal
D. Trigonometric Identities	3	41	Satisfactory
E. Trigonometry	5	53	Satisfactory
F. Systems of Equations	2	54	Marginal
G. Inequalities	3	40	Marginal
H. Progressions	3	44	Marginal
I. Permutations, Combinations, and Binomial Theorem	5	61	Very Satisfactory

A. Relations and Functions

The Relations and Functions subtest contained items from the grade eleven and the grade twelve curriculum. Functions and functional notation are introduced in Mathematics 200 followed by a detailed study of specific functions and relations in Mathematics 300.

The students' ability to distinguish between a function and a relation was poor. The vertical line test was performed correctly by 52% of the students, but less than 26% could identify functions described by the rule method.

Similarly, over 82% of the students were able to find the value of a quadratic function for a given negative integer argument; while only 49% correctly selected E in the following item.

106. If functions f and g are defined by $f(x) = x - 1$ and $g(x) = (x+3)^2$, then $g(f(x))$ is

A) $x^2 + 8$

B) $x^2 + 4$

C) $(x+3)^2 - 1$

D) $(x+1)(x+3)^2$

*E) $(x+2)^2$

An item typically found in the conic section chapter of Mathematics 300 textbooks was answered correctly by less than 38% of the students. This was possibly due to the test date. As this topic is usually the last to be covered in the curriculum, many students may not have covered this topic at the time of writing the test.

B. Exponential and Logarithmic Functions

The Interpretation Panel gave a "satisfactory rating" to the results on this subtest. Although the results were somewhat low, some Panel members felt that because calculators and/or mathematical tables were not allowed during the test that the students were faced with responses written in an unfamiliar format.

The students' ability to use the definition of a logarithm produced inconsistent results. Over 73% correctly selected E in the following item.

108. The exponential form of $\log_a 8 = 3$ is

A) $3^a = 8$

B) $3^8 = a$

C) $a^8 = 3$

D) $a^{-3} = 8$

*E) $a^3 = 8$

Yet, less than 59% correctly selected C in

111. If $x = \log_2 64$, the value of x is

A) 4

B) 2

*C) 6

D) 8

E) 5

The students' ability to use logarithms to solve an exponential equation and a compound interest problem was very poor. Less than 29% solved the former problem correctly and only 34% were able to find the latter solution.

C. Circular Functions

In the Circular Functions subtest the students encountered much difficulty specifying solution sets and their performance was rated "marginal". The following item caused real difficulty with only 30% answering correctly.

118. The zeros of the cosine function, $\cos:\theta \longrightarrow \cos\theta$, are located at

A) $k\pi$ where k is an odd integer

B) $k\pi$ where k is an even integer

C) $\frac{k\pi}{4}$ where k is an integer

D) $\frac{k\pi}{2}$ where k is an even integer

*E) $\frac{k\pi}{2}$ where k is an odd integer

About 80% knew the definition of $\tan\theta$ on the unit circle and slightly more than half correctly evaluated $\cos\frac{\pi}{3}$.

D. Trigonometric Identities

The results on the Trigonometric Identities subtest were very poor. The Interpretation Panel members felt that perhaps expectations may have been too high considering the nature of the test. The poor performance may have been due to the fact that most students are presented with both sides of the identity when doing classroom exercises and tests.

E. Trigonometry

The students' performance on the Trigonometry subtest was better than on the Circular Function subtest. However, their ability to solve word problems was poor. Less than 39% were able to solve the following problem.

129. At a height of 6000 units a pilot of an airplane measures the angle of depression of a light at an airport as 25°. The direct distance from the pilot to the light is

A) $6000 \tan 25°$

B) $6000 \tan 65°$

C) $\frac{6000}{\sin 65°}$

D) $\frac{6000}{\cos 25°}$

*E) $\frac{6000}{\sin 25°}$

Hopefully the poor result can be attributed to the somewhat unfamiliar format of the answers caused by not allowing calculators and/or mathematical tables during the test.

F. Systems of Equations

This subtest contained only two questions. Less than 57% of the students were able to correctly evaluate a 3x3 determinant, and about 50% were able to solve a system of three linear equations for one of the variables - hence, the "marginal" rating.

G. Inequalities

The Interpretation Panel also gave a "marginal" rating of the students' ability to solve inequalities. Many students appeared to use the techniques used to solve an equation. However, they seemed to disregard the restrictions of the inequality and the various functions. The following items should illustrate this.

132. The solution for x in $|x - 5| < 6$ is

*A) $-1 < x < 11$

B) $-5 < x < 5$

C) $-1 < x < 6$

D) $x < 1$ or $x > 11$

E) $x < -1$ or $x > 6$

The reader should note that only the correct solution (A) contains the phrase $x < 11$ which would be the solution to $x - 5 < 6$.

134. The solution for x in $\frac{1}{x-3} > 2$ is

*A) $3 < x < \frac{7}{2}$

B) $x < \frac{7}{2}$

C) $x > 3$

D) $x < 3$ or $x > \frac{7}{2}$

E) $x > \frac{7}{2}$

The majority of the students incorrectly chose B. It seems, they completely ignored the possibility of $x - 3$ being negative. They simply proceeded as follows

$$1 > 2x - 6$$

$$7 > 2x$$

$$\frac{7}{2} > x$$

Only 17% correctly selected A, while almost 30% incorrectly selected B.

H. Progressions

Although the Interpretation Panel gave the Progressions subtest a "marginal" rating the only question answered correctly by more than 35% of the students was:

135. The sequence of numbers whose first four terms are $\frac{3}{4}$, 2, $3\frac{1}{4}$, $4\frac{1}{2}$ is called a(n)

A) harmonic progression

B) geometric progression

C) convergent series

*D) arithmetic progression

E) not a progression

Less than 69% of the students could recognize this sequence as an arithmetic progression. Considering that some students only study the geometric and arithmetic progressions, they were probably limited to one of two choices, B or D.

I. Permutations, Combinations and Binomial Theorem

The Permutations, Combinations, and Binomial Theorem subtest received the highest rating of any subtest - "very satisfactory". The expansion of the binomial expression $(2x - 1)^4$ was simplified correctly by over 67% of the students. The only apparent weakness was that many students, 37%, think that $0!$ has a value of 0.

Results by Cognitive Level

The Interpretation Panel's rating of performance across topic areas in each of the three

designated cognitive levels is shown in Table VI-9.

TABLE VI-9

Mathematics 300: Results by Cognitive Level

Cognitive Level	No. of Items	Average Percent Correct	Interpretation Panel Rating
Knowledge and Computation	8	61	satisfactory
Comprehension	18	56	satisfactory
Application	16	40	marginal

The Interpretation Panel felt that the material covered in Mathematics 300 requires more instructional time for adequate mastery. In light of this fact, the members considered the students' performance to be good. They also felt the scores were affected by the fact the test was written before all of the material on the course was covered in class.

MATHEMATICS 301 RESULTS

The actual results together with the ratings of the Interpretation Panel are shown in Table VI-10. Each of the subtests will be discussed in turn. For item detail the reader is referred to Volume IV of the Preliminary Report.

TABLE VI-10

Mathematics 301: Results on Subtests

Subtest Within Topic Area	No. of Items	Average Percent Correct	Interpretation Panel Rating
A. Sequences	4	37	Satisfactory
B. Exponents	7	64	Satisfactory
C. Logarithms	5	32	Marginal
D. Trigonometry	6	32	Marginal
E. Polynomials, Rational Expressions and Quadratic Relations	8	55	Marginal
F. Ratio, Proportion and Variation	7	52	Marginal
G. Interest and Annuities	2	46	Marginal
I. Mathematics of Chance	4	41	Marginal
J. Statistics	2	35	Unsatisfactory

A. Sequences

Although the results on the sequence subtest were rather low a "satisfactory" rating was given by members of the Interpretation Panel. They felt that if the students had been provided with progression formulae the results would have been much better. This conjecture is

supported to some extent by the results on the following item:

132. The 20^{th} term of the sequence $\frac{1}{6}, \frac{1}{18}, \frac{1}{54}, \ldots$ is

A) $\frac{1}{6}(2)^{20}$

B) $\frac{1}{6}(2)^{19}$

C) $\frac{1}{6}(\frac{1}{3})^{20}$

*D) $\frac{1}{6}(\frac{1}{3})^{19}$

More than 37% of the students incorrectly selected C, replacing the exponent in the formula $t_n = t_1 r^{n-1}$ by n.

B. Exponents

The subtest on exponents produced the best results. The conversion from scientific notation to standard notation, and vice versa, yielded the highest scores. The students' performance in multiplication and division of monomials was also very good. The only apparent weakness was in raising a negative integer to a fractional exponent.

C. Logarithms

In the logarithm subtest it was apparent that students were very weak on the definition of a logarithm. Four items dealt with the definition. On three of these items the percent correct was below 35%. On the fourth item the percent correct was 51%, but this higher percent may have been produced as a result of the format of the question

110. The value of the antilog $_{10}2$ is

A) 2

B) 5

C) 20

*D) 100

The students may have selected the correct response by ignoring the antilogarithm function and simply squaring 10.

Many educators feel that calculations with logarithms are unimportant because a calculator is more efficient. With this in mind, if logarithms are to be taught in school, the emphasis should be on the properties of the function, beginning with its definition. Thus it is surprising how poorly the students performed on definition items. Some members of the interpretation panel felt that the weakness may be due to the different approach used in Mathematics for a Modern World. This fact influenced the Panel's rating of "marginal".

D. Trigonometry

The trigonometry subtest results were also very disappointing. Members of the interpretation panel again felt that if the sine and cosine laws had been provided the results would have been much better. Yet, it is surprising that only 30% of the students successfully

solved the following standard trigonometry problem:

116. The angle of elevation of the sun is 35°. If the shadow cast by a pole is 15 m, then the height of the pole is

A) 15 sin 35

B) 15 cos 35

*C) 15 tan 35

D) none of these

Hopefully, the poor result on this item is due to the somewhat unfamiliar format of the solution. Indeed, the Interpretation Panel found it difficult to arrive at a rating of the logarithm and trigonometry subtests because mathematical tables and/or calculators were not allowed during the test. This resulted in answers with formats different from those to which the students were accustomed. Therefore, although the results were very poor, some members of the panel questioned the validity of the test items. These individuals felt that on this basis the results were "satisfactory".

E. Polynomials, Rational Expressions, and Quadratic Relations

The results on the polynomial subtest received a "marginal" rating because they varied from a high score of 85%, when the students were asked to find the product of two binomials, to a low score of 38%, when the students were asked to solve a quadratic equation given the quadratic formula.

The low score on the latter problem is somewhat surprising considering the Interpretation Panel's impression that stated formulae in subtests such as progressions and trigonometry would have produced much better results. However, polynomials are not taught as part of the mathematics 301 curriculum in some schools. Some review of mathematics 201 curriculum before the test would probably have improved the scores on this item.

In reviewing answers students chose for some specific items it becomes apparent that students at this level must be taught to pay special attention to the wording of the questions. For example,

125. The complete factorization of $x^4 - 16$ is

A) $(x^2 + 4)(x^2 - 4)$

*B) $(x - 2)(x + 2)(x^2 + 4)$

C) $(x - 2)^2(x + 2)^2$

D) $(x^2 - 4)^2$

Only 30% of the students correctly chose B, whereas 49% selected the partially completed solution A.

F. Ratio, Proportion, and Variation

In this subtest the carelessness with wording is again apparent in the following item.

135. There are 12 boys in a class of 36 boys and girls. The ratio of boys to girls in this class is

*A) 1:2

B) 3:1

C) 2:1

D) 1:3

Less than 44% correctly chose A, while 45% selected D which stated the ratio of boys to students.

An item that caused much difficulty was one which students should have been able to solve without performing any calculations.

141. Y varies directly as X and inversely as the square of Z. The effect on Y when X is quadrupled and Z is doubled is

A) Y is quadrupled

B) Y is doubled

*C) Y is unchanged

D) Y is $\frac{1}{4}$ of its previous value

Only 32% of the students selected the correct response C.

The last three subtests: Interest and Annuities, Mathematics of Chance, and Statistics are optional topics. Thus not all students writing the test had taken these topics.

G. Interest and Annuities

The Interest and Annuities subtest contained only two items. A simple interest item (68% correct) and a compound interest item (24% correct).

I. Mathematics of Chance

The Interpretation Panel felt that at the time of writing the test many students had not covered, as yet, the Mathematics of Chance. However, students had encountered factorial notation as is evident by the relatively high score (52% correct) on the following item.

142. The value of $\frac{6!}{2!}$ is

A) 6

B) 18

C) 24

*D) 360

J. Statistics

Similar comments were made on the statistics subtest. The Interpretation Panel felt that the topic is not taught in many schools.

Results by Cognitive Level

The Interpretation Panel ratings of performance across topic areas in each of the three designated cognitive levels is shown in Table VI-11.

TABLE VI-11

Mathematics 301: Results by Cognitive Level

Cognitive Level	No. of Items	Average Percent Correct	Interpretation Panel Rating
Knowledge and Computation	19	53	Satisfactory
Comprehension	16	49	Satisfactory
Application	10	36	Unsatisfactory

The satisfactory ratings were given in the first two categories taking into account the nature of the students and the somewhat unfamiliar format of the test.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

12-General

1. The most obvious weakness is in geometry, where performance was considered unsatisfactory for two of the three groups of students.

RECOMMENDATION: That the teaching of basic geometric content, skills, and terminology in courses at earlier grade levels be reviewed.

2. The area of algebraic skills should have been better handled by the Mathematics 300 and 301 groups. The number of items in this category (4) is perhaps too small to justify any sweeping conclusions, but certainly we must ask why these particular groups of students did not perform better.

3. The low performance on Number Systems and Operations by students with no grade 12 math is, at least in part, due to difficulties with integers (signed numbers) and fractional percents. As a reflection of the curriculum this performance suggests that objectives are not being met. With respect to life skills in mathematics, however, the achievement level within these topics may be of less concern.

Mathematics 300

1. Results were thought to be affected by the date of the examination and the lack of calculators, the latter affecting answer format, the former rendering some items invalid.

2. Lack of motivation for the assessment test and no preparation for it may have affected the results. In order that both students and teachers gain the maximum benefit from the assessment programs, we make the following recommendation:

RECOMMENDATION: That if future assessment programs, teachers be strongly encouraged to incorporate the assessment tests into their instructional evaluation programs.

3. The poor results in the Circular Functions subtest suggest that it may be worthwhile for teachers to spend some time in teaching students how to specify some standard sets of numbers.

RECOMMENDATION: That teachers review their teaching of this material and consider the following developmental example as a means of achieving this objective.

Verbal		
even integers	are denoted by	$2k$
odd integers	are denoted by	$2k+1$ (or $2k-1$)
odd multiples of $\frac{\pi}{2}$	are denoted by	$(2k+1)\pi/2$

4. Difficulty in the section on Trigonometric Identities suggests that it may be beneficial for students to use identities to simplify trigonometric expressions.

RECOMMENDATION: That teachers review the method they are using for the simplification of trigonometric expressions and consider alternative approaches.*

5. The poor performance on the Progression subtest may be because the prevalent textbook, Introduction to Modern Mathematics (Vance) contains only three exercises on the topic.

RECOMMENDATION: That teachers review their teaching of Progressions, and supplement the topic with additional exercises if the text they are using has a limited number of practice problems.

6. The overall performance of Mathematics 300 students is not strong. While as suggested above, motivation may be a factor in this performance, there are other factors. A number of these are discussed in Chapter VIII in connection with the Teacher Survey Results.

RECOMMENDATION: That the following be reviewed: 1) the mathematical background required for a student to be successful in Mathematics 300, and 2) the counselling of students to enroll in Mathematics 300. See also the recommendations regarding Mathematics 300 in Chapter VIII (pp. 82).

Mathematics 301

1. The issue of calculators (not permitted for the assessment test) was thought by most interpreters to affect the test results. Disagreement on the validity of certain test items was a consequence of the absence of calculators.

RECOMMENDATION: That students be permitted the use of electronic calculators in future mathematics assessments.

2. Student weaknesses in the understanding of the properties of logarithmic and exponential functions may be due to the approach used in current textbooks, especially Mathematics for a Modern World.

*One approach considered effective is that of the Fisher and Ziebur text: Integrated Algebra and Trigonometry with Analytic Geometry.

RECOMMENDATION. That teachers stress the properties of logarithmic and exponential functions over calculations (which can be better performed with a calculator).

3. Results in several subtests suggest that questions were not always read carefully.

4. Students seemed to be unable to appreciate how a dependent variable is affected by changes in the independent variable(s).

RECOMMENDATION: Place more emphasis on oral responses to variation problems. For example,

What is the effect on X in each of the following Y, Z and W are doubled?

(a) $X = kY$

(b) $X = \frac{k}{Y}$

(c) $X = kYZ$

(d) $X = \frac{kY}{Z}$

(e) $X = kY^2$

(f) $X = \frac{k}{Y^3}$

CHAPTER VII

TRENDS AND COMPARISONS

This chapter is divided into three main sections. The first one presents comparisons of performance at different grade levels on common items. The second is focused on differences in performance by males and females. The third section discusses performance in geometry and measurement across the four grade levels tested in the assessment program.

COMMON ITEMS

While comparison of data between grade levels was not a major aim of the assessment program, a number of items were common to more than one grade level. At the grade 12 level, common items appeared only on the 12-General test.

On the following two items grade 12 students with no grade 12 mathematics scored less well than did grade 9 students--differences favoring grade 9 by 22% and 18% for the two items respectively.

Which of the following equals 8?

*A) 2-(-6)
B) (-2)+(-6)
C) (2)+(-6)
D) (-5)-(3)
E) (-5)-(-3)

Written as a percent, 0.025 =

A) 25%
*B) $2\frac{1}{2}\%$
C) $\frac{1}{4}\%$
D) $2\frac{1}{4}\%$
E) $1\frac{1}{4}\%$

On the other hand, one item was well handled by all grade 12 students, but was correctly answered by less than half of the grade 9 students.

A salesman receives 20% of the retail value of his sales as commission. What must his total retail sales be if he is to earn a commission of $60?

A) $80
B) $1200
C) $120
D) $3000
*E) $300

Thus, although grade 9 students may have more recently practiced the computational skills involved in this problem, their lack of maturity may have caused the weaker performance.

Two similar items at the grade 9 and 12 levels on finding an arithmetic mean of three numbers produced good results (over 70% correct) in each case. Each of the two tests had an item on interpretation of data in a circle graph. Although the items were not identical, the tasks were the same, namely to find the amount belonging in a specified sector given the percents of each of the other sectors. This required students to first calculate the percent of the specified sector, and then find that percent of the total amount (number). Grade 12 students performed significantly better than students in grade 9. In the latter group only 42% correctly answered the item, while at grade 12 level the overall percent correct was above 80% for students

with and without grade 12 mathematics.

One measurement item was similar at grades 3, 6, and 12. It called for recognizing the length of a crayon (grades 6 and 12) or a leaf (grade 3). The distractors at grade 3 were slightly different, but in both cases the correct response was 10 centimetres. The percents correct at the three grade levels were approximately 70%, 80% and 90% respectively--a good overall showing.

SEX DIFFERENCES IN ASSESSMENT PERFORMANCE

For all subtests at each grade level, statistical tests of significance (at the .05 level) were conducted on the mean percentage correct for males and females. A limited number of significantly different means were detected, and a few trends across grade level were noted; some of these were at odds with differences found in other studies. Recent literature on mathematics education contains numerous articles on the differential performance of males and females. In particular, reference was made to the findings of the National Assessment of Educational Progress (NAEP) second mathematics assessment in the United States as reported by Fennema and Carpenter (1981) and to the findings from the Alberta mathematics assessment program as reported by Sawada, Olson, and Sigurdson (1981). This summary report, however, will refer only to the above studies and to other assessment findings from Manitoba. A more detailed study of this complex issue belongs elsewhere.

The data is examined and discussed by topic area for the grade 3, 6, 9, and 12 general tests. The course specific tests from grade 12, 300 and 301, will be treated separately. The number of items in some topic areas is not large, and certainly smaller than the numbers used in the comparison studies noted above. Furthermore, the topic area definitions and the actual items used differ from one investigation to another. However, such comparisons should be noted, with the caveat that any interpretation must be made with these limitations in mind.

Number Systems, Operations, and Properties

At the grade 3 level no significant differences were found within this topic area. This is contrary to the findings of NAEP (Fennema and Carpenter, 1981) in the United States and Sawada, Olson, and Sigurdson (1981) in Alberta. The cited studies found that females at this level (age 9 and grade 3, respectively) scored higher on numeration skills than did males.

At the grade 6 level, the significant differences which did occur within the first topic area all favored the girls. This happened on five subtests, namely:

I.J	Properties
I.KL	Addition and Subtraction of Whole Numbers
I.M	Multiplication of Whole Numbers
I.N	Division of Whole Numbers
I.STU	Operations with Decimals
I.W1 and W2	Word Problems

Again this seems to contrast the Alberta findings which showed boys well ahead of girls even on these basic numerical skills by grade 6. The NAEP did not test children by grade level, but did test 13-year olds. These students are slightly older than Manitoba grade 6 students. Among American 13-year olds, girls scored higher in all categories on number and numeration exercises except application (word problems).

By grade 9, the achievement of Manitoba boys and girls shows few differences and are as much in one direction as the other. In Alberta the results again favour the boys. No U.S. testing was completed by NAEP at this level.

At the grade 12 level the mean score for boys did not differ significantly from that for girls in this topic area. In Alberta, on the other hand, boys consistently outscored the girls. The NAEP results are similar to Alberta's, with boys outscoring girls in all subcategories of the topic.

Measurement

In the topic area of measurement, a number of significant differences were found in the Manitoba results, but no trends appear to be indicated. Only at the grade 3 level was the topic broken down into subtests for analysis. In three out of the four subtests the boys performed significantly better. On the fourth subtest there was no significant difference. This result confirms the findings of both the NAEP and the Alberta study that boys outperform girls in measurement.

This trend manifested itself at all four grade levels and is consistent with the other studies which show boys scoring higher on measurement items at all levels. At the grade 12 level, however, among those groups enrolled in Mathematics 300 or 301, no significant differences appeared; overall performance was high for both groups in this topic area.

Geometry

Only at the grade 12 level and only for the "no grade 12 mathematics" group did significant differences in performance of boys and girls appear in geometry. This difference strongly favoured the males. Here again the Manitoba results run counter to the Alberta and American findings. In both of these investigations males performed significantly better in geometry over all cognitive levels at all ages tested. Fennema and Carpenter (1981) suggest that perhaps an explanation for the NAEP findings is that a substantial number of their items involved spatial visualization skills and from about mid-adolescence females perform at lower levels than males on this skill. Such skill was not heavily demanded by the items on the Manitoba tests.

Graphing

"Graphing" included skills related to the construction and interpretation of data representation graphs such as line graphs, circle graphs, bar graphs, and pictographs. At the two upper levels the topic area was referred to as "Graphing and Statistics" and included items involving the arithmetic mean.

Only at grade 6 and among 301 math students was there any significant difference in performance by sex. The boys scored higher than the girls. Within this category comparisons with the findings of other investigations are inappropriate because of the way in which topic areas are defined. The categorization used in the Manitoba assessment does not correspond to any category employed elsewhere.

Word Problems--Grade 6 Only

At this one grade level a separate analysis was done for word problems: one-step and two-step. These items all come from the topic area of Number Systems, Operations, and Properties. For both types of problems females scored better than males. While this is not directly comparable to findings of one of the other investigations, Fennema and Carpenter (1981) do present data from NAEP for 13-year olds on one-step and multi-step word problems. In the NAEP investigation males scored higher on both types of problems.

Consumer Applications--Grade 12 Only

In only one group of grade 12 students did significantly different performances by sex occur on the grade 12-General test. Among Mathematics 301 students the males outperformed the girls on a set of consumer application items.

Mathematics 300 and 301 Tests

Mathematics 300. The content of Mathematics 300 was divided into nine topic areas. In three of these areas, namely Relations and Functions, Exponential and Logarithmic Functions, and Circular Functions, males performed significantly better in a statistical sense. However, in all other areas but one, Systems of Equations, males also outperformed females, although the differences were not statistically significant. Hence, in overall performance the males are at a higher level.

Mathematics 301. On the nine subtests which made up the Mathematics 301 assessment, statistically significant differences in performance by sex were found for only two: Interest and Annuities, and Statistics. In both cases males scored higher than females. Other differences in mean scores favoured females as often as males but were not statistically significant.

Sex Differences: Summary

Numerous articles have appeared in the mathematics literature of the last five or six years dealing with sex differences in mathematical performance. The findings in Manitoba are not always in agreement with those of other investigations. In fact, over the entire range of subtests, the number of significant differences favouring males is 11, while the number favouring females is 10. All other differences are not statistically significant. Thus, with the exception of a few specific areas, overall performance of boys and girls was found to be equivalent in these general mathematics courses.

For the grade 12 course specific tests, the overall results clearly favour the males, a finding which mildly supports the stronger NAEP and Alberta results.

With regard to differences in performance by sex, the Manitoba results show only marginally better performance by males than females. Although no remedial or corrective action is recommended at this time, the situation should be carefully monitored in the future.

GEOMETRY AND MEASUREMENT

Geometry was an element of the assessment of every grade level. While most of the geometry items were included in the geometry subtests, at each level other than grade 12, items also appeared in the measurement section. The latter included especially those items dealing with the calculation of areas and perimeters at grades 3, 6, and 9. Furthermore, two items on the Pythagorean relation given at grade 9 were placed in the topic area of Number, Systems, Operations, and Properties because they were viewed as dealing with irrational numbers.

With few exceptions all of these geometry items were poorly handled by students. The only exceptions to the trend in this basic branch of mathematics was performance on a set of items on terminology in geometry and on perimeter at grade 3, and the generally very satisfactory performance by Mathematics 300 students. Beyond these bright spots, performance at all grade levels was judged as "marginal" or "unsatisfactory".

Geometric terminology, even such basic notions as "diameter", were poorly understood. Area and perimeter problems yielded the best results, but only if they were very straightforward. Finding the length of a side of a right triangle given the other sides (using the Pythagorean relation) was accomplished by less than 40% of grade 9 students and by less than 62% of Mathematics 301 students. Approximately 54% of grade 12 students with no mathematics were able to calculate such a length.

All of the objectives tested by these geometry items not only appear in the respective grade level provincial curriculum guides, but were rated by teachers as important. If these test items are in fact representative of the desired objectives, then something is clearly amiss in the instructional program.

RECOMMENDATION: That teachers and school divisions, and the Curriculum Branch of the Department of Education, examine the teaching of geometry and measurement with a view to insuring that <u>at least</u> the specified curriculum is taught in grades 1-11.

REFERENCES

Fennema, E. and Carpenter, T.P. Sex-related Differences in Mathematics: Results from National Assessment. <u>The Mathematics Teacher</u>, 1981, <u>74</u>, 554-559.

Sawada, D., Olson, A.T., and Sigurdson, S.E. Sex Differences in Mathematics Learning in a Canadian Setting, <u>Canadian Journal of Education</u>, 1981, <u>6</u>, (2), 5-19.

CHAPTER VIII

TEACHER SURVEY

The teacher survey was designed to collect information which would assist in the general interpretation of the student assessment data and be of value to curriculum development committees and teacher educators in establishing goals with respect to new programs, availability of resources, and inservice professional development. Such factors as time spent on various activities in the classroom, the availability of materials, the degree of implementation of the new curriculum guides, and the attitudes of teachers should be considered when attempting to interpret the assessment results. The data and its analysis will not provide cause-and-effect relationships, but gives a cross-section of opinion. The general information obtained will not explain specific student results, but does establish generalities regarding programs. Teachers of mathematics in grades 3, 6, 9, and 12 were surveyed as their students were participating in the assessment. Recommendations based upon the survey data are presented at the conclusion of the chapter.

The details of teacher responses to the questionnaires are not presented in the Report. They are available on request from the Measurement and Evaluation Branch.

THE SURVEY

The survey consisted of four questionnaires, one each for teachers of grades 3, 6, 9, and 12. The questionnaires were designed to assess teacher practices and opinions in a number of areas, which differed in specifics by grade level. All questionnaire items fall into one of the following eight categories:

Demographic Data. This includes the present and past teaching experience of the responder and how many classes he/she teaches.

Classroom Organization. Items in this category identify the number and type of classes now being taught, the classroom structure, the number of hours of mathematics taught per week, and for secondary schools whether the school is on a full-year or semester system.

Classroom Activities. This series of items attempts to ascertain the kinds of activities which receive emphasis in the classroom.

Use of Curriculum Guides, Textbooks, and Other Resource Material. The several sets of items in this category ask for teacher views on usefulness of various report materials, including Department of Education Curriculum Guides, concrete materials, and commercially prepared texts and teacher's guides.

Use of Calculators and Computers. Items here reflect present calculator and computer use and teachers' view on future use of these tools.

Classroom Evaluation Techniques. A series of items in this category sought to determine actual teacher practices in the area of student evaluation.

Teacher Views on the Student Assessment. A six-part item at each grade level sought views on teachers' opinions regarding the student assessment program at that grade level.

Curriculum and Instruction. For the two elementary grades these items focussed on instruction and instructional materials related to the curriculum at those levels. At grade 12 a pair of items was included which dealt with curricular objectives in each of the two grade 12 courses. At grade 9 no items fell into this category.

During the development of the questionnaire, input was considered from the Technical Advisory Committee, the Contract Team, the Joint Committee on Evaluation, the Mathematics Working Party (K-12), and teachers at regional meetings. Questionnaires were mailed to all public schools in the province to coincide with the testing dates in May 1981. All mathematics teachers with students involved in the assessment were requested to complete and return the questionnaires. These instruments were self-administered and strict confidentiality was maintained by the Department. Results were analyzed for the province as a whole with no individuals, schools, or school divisions being identified. The number of completed questionnaires at each grade level is indicated in Table VII-1.

Table VII-1
Number of Returned Questionnaires by Grade Level

Grade Level	Number of Returned Questionnaires
3	582
6	554
9	229
12	162

Survey results will be discussed by the eight categories for elementary and secondary groups separately. This format should clarify trends across levels.

GRADES 3 AND 6: SURVEY RESULTS

About three-fourths of the teachers responding to the grade 3 survey had past as well as current teaching experience at the grade 3 level. Less than 10% had any teaching experience above grade 6 and virtually all teach their mathematics in a self-contained classroom with no departmentalization. Over 90% teach three hours of mathematics or more per week, often more than four hours per week. At the grade 6 level patterns are only slightly different. At least 15% of these teachers have had some junior high (grades 7 and 8) teaching experience. Most teach math to only one class, and for about four hours per week.

At both grade levels just over 20% of respondents teach two grade levels in one classroom, and 11% have three or more grade levels. About 80% of the classrooms are self-contained and 17% are open-area. In both grades 3 and 6 more than half of the time instruction is aimed toward the total class. Grade 3 teachers indicated almost 40% small group instruction and 5% individual instruction. For grade 6 these figures were 27% and 9% respectively.

Classroom Activities

The frequency of use of concrete materials is slightly higher in grade 3 than in grade 6, but the reverse is true of time spent solving textbook exercises. At both levels little

opportunity is provided for work on creative mathematics projects. Activity centres are more commonly used in grade 3, as is drill on basic number facts.

Use of Curriculum Guides, Texts, and other Resource Material

At the grade 3 level 75% of the respondents found the 1978 K-6 Mathematics Curriculum Guide "useful." At the grade 6 level the figure was just over 70%. All seven aspects of the Guide, that were listed, were rated 3 or better on a 5-point scale (Not at all useful to Very useful) by 60% or more of the respondents at both grade levels. This indicates that the Guide has been well received and is being used.

Other Department of Education material is less well received--about 30% at each grade level find it "useful", but most of the remainder see it as only "minimally useful" or "not useful". Division or school developed resource materials were rated slightly higher than Department material by grade 3 teachers, but rated lower by grade 6 teachers. Professional journals were found useful by less than 30%, although books of ideas for student activities were found useful by a majority of teachers at both levels.

Investigating School Mathematics was the most commonly used textbook in both grades 3 and 6, being used in over 50% of classrooms. At grade 6, 45% use it as the basic or predominant textbook; at grade 3 this figure is only 30%. Starting Points in Mathematics is used at the grade 3 level by almost 20% of the responding teachers, but few other texts appear to be widely used, except occasionally as additional resources. The overall finding is that none of the textbooks listed, except as noted above, is widely used. On the other hand in both groups more than 60% say that they use one textbook only or one predominantly. A majority also favors the current policy of allowing a teacher to choose from among several recommended textbooks.

In general, over 85% find textbooks and accompanying Teacher's Guides useful or very useful. Similarly, materials obtained through workshops are rated as useful. Commercial resources, Department of Education library and film resources, and ideas obtained through university courses were found to be moderately useful.

A list of twenty-one types of material resources, from films to chalkboard and attribute blocks to videotapes, was presented in the survey instrument for teachers to rate frequency of use. Only a few were used more than occasionally, among them were (1) chalkboard--very frequent use (80%), (2) commercially prepared duplicating masters--frequent use (grade 3: 32%; grade 6: 22%), (3) teacher prepared handouts--frequent (over 35%), and (4) metric equipment--frequent (25%). These items were rated almost identically by the teachers at the two grade levels. A few further materials were used frequently only at grade 3 level: (1) commercially prepared games (23%), (2) teacher prepared games (31%), (3) teacher prepared activity cards (27%) and (4) counters of various sorts (25%). These items reflect the greater activity orientation of the grade 3 classroom.

Use of Calculators and Computers

First the electronic calculator and more recently the microcomputer have made their appearance in the elementary school classroom. At the time of the survey it was felt that calculators were generally available and that, even if not used in the classroom, they were used

by children outside of school. Microcomputers on the other hand are just beginning to be used in elementary schools. It was thus decided to survey use of calculators only at this time.

A limited number of grade 3 and 6 teachers saw calculator use being restricted for arithmetic calculations per se. Other calculator uses were overwhelmingly supported--by over 58% in all cases--with the mean percentages slightly higher at the grade 6 level than at the grade 3. Despite this strong support, significant opposition (in some cases over 20%) exists for the use of calculators in schools.

Classroom Evaluation

An item on formal evaluation in the mathematics class suggested ten approaches to such evaluation and asked teachers to rate their emphasis in a four-point scale. While percentages differ slightly from grade 3 to grade 6, the relative emphases of the various approaches form similar patterns at the two grade levels. Teacher prepared classroom tests and teacher observation of day-to-day working habits received high emphasis, closely followed by teacher marking of daily student work. Commercial test materials received little attention as did division-wide tests.

Teacher Views of the Assessment Program

A series of items designed to ascertain teacher perceptions of the student assessment program netted a very favorable response at both grade levels. In grade 3 more than 70% rated the match of skills taught and skills tested as 4 or 5 on a five-point scale, an average overall rating of 3.90. The level of difficulty was given a mean rating of 3.87, with over 65% in the top two ratings. Overall satisfaction was rated 4 or 5 by 62% of the respondents, and received a mean rating of 3.70. Sixty-eight percent indicated that they were planning to use the test as part of their instructional evaluation program. Almost 85% said that if these mathematics skills were to be tested again in the future, they would likely request enough copies of the test for their entire class. One further question on the usefulness of the test clusters identified in the Scoring Key gained a mixed response, but with favorable outnumbering unfavorable responses. The mean rating of 3.21 with over 40% rating it at 4 or 5 suggests the spread of ratings.

A not dissimilar picture obtains in grade 6. Over 75% of the respondents rated the match of skills tested and taught at 4 or 5. The mean rating was 4.08. On level of difficulty of the test a similar degree of satisfaction was expressed with a mean rating of 3.96. Overall satisfaction was only slightly less, with 68% rating it 4 or 5 and a mean of 3.87. Sixty-one percent indicated that they were planning to use the test as part of their instructional evaluation program and 86% said that if such skills were tested again in the future they would request enough copies to test their entire class. With respect to the usefulness of the Scoring Key clusters, about 80% indicated a 3 or better, yielding a mean of 3.53.

In summarizing this section, it is evident that satisfaction with the assessment testing program was quite high and that teachers would be willing to use such tests in their classrooms in the future.

Curriculum and Instruction

The last section of the survey for the two elementary grades gave teachers an

opportunity to indicate the elements of mathematics instruction which they see as important. More specifically, the question asked was:

> The following statements represent a number of factors that could affect mathematics instruction. What importance would you assign to each based upon the affect it would have on the success of your grade 3 (6) mathematics program?

"Better mathematics textbooks" was considered moderately important or very important by over 60% of grade 3 teachers and by over 70% of grade 6 teachers. "Better study workbooks" received no clear cut rating, but "curriculum materials that provide more instructional assistance" was rated moderately or very important by almost 70% of grade 3 teachers and by almost 60% of grade 6 teachers. "More mathematics manipulative materials" was thought to be highly important by 73% of grade 3 respondents and 62% of those teaching grade 6. Development of "finger" mathematics was viewed as being of minimal or no importance by 66% of grade 3 teachers and only 24% saw it as important. At the grade 6 level almost 80% view it as unimportant.

When asked if more time should be allotted to mathematics, a majority of respondents at each grade level indicated that this was moderately important or very important while roughly 30% called it minimally important. Finally, "computer assisted instruction" was viewed as unimportant by almost half (46%) of grade 3 respondents and 28% saw it as minimally important. Grade 6 teachers attached only slightly more importance to it: 29% rated it moderately or very important while 65% rated it minimally important or not important.

In summary, the strongest case was made for better mathematics textbooks, more manipulative materials, and curriculum materials that provide more instructional assistance. More time for mathematics was seen as desirable by many. "Finger" mathematics and computer assisted instruction were generally viewed as having little or no importance, although each had its advocates.

GRADES 9 AND 12: SURVEY RESULTS

Demographic Data and Classroom Organization

Of the 162 grade 12 teachers responding to the questionnaire, about 15% indicated that they had past teaching experience at the K-6 level, while about 60% had previous experience in the junior high school (grades 7-9), and one half of these continue to teach at this level. A majority of grade 12 teachers also teach math at grades 10 and 11. About 10% indicate that they are teaching an optional Math 305 course and 12% that they are handling computer science/data processing.

Most (68%) grade 12 teachers indicate that 80% or more of their teaching load is in mathematics, while 16% indicate that about 60% of their teaching time is in mathematics.

Less than 10% have been principal or vice-principal although over 30% have been or are department heads in mathematics.

Among grade 9 teachers only slightly over half have a 60% or more load in mathematics. Thus many grade 9 math teachers are also teaching other subjects. About 30% of the respondents indicated that they also had teaching experience in the elementary school (K-6), and just slightly more than that had also taught in grades 10-12.

Approximately 30% of Math 300 respondents and 20% of Math 301 respondents indicated they were presently teaching these courses in a full-year system. The remainder are in semester systems. At the grade 9 level 80% indicated a full-year organization. While a wide range of "hours per week" was listed under both systems, it would appear from the Math 300 respondents, for example, that on the average a semester class has about 10 hours less instruction than the full-year course.

For both grade 12 groups, 300 and 301, and grade 9 teachers an identical question was asked regarding teachers' views of the semester system. This data is presented in Table 2. While a majority of grade 12 teachers have probably taught under both organizations, many grade 9 teachers have not. The data suggest strongly that teachers feel that more and better mathematics learning takes place under a full-year system as opposed to a semester system. The only exception to a preference for the full year is in the average student motivation. Here Grade 9 teachers still see the full year system preferred while Math 300 teachers see it as a "toss-up", and 301 teachers tend to find the semester system as more motivating.

Table VIII-2

Teacher Views of the Semester System with Respect to Mathematics Learning
(% of those returning Questionnaire)

	Full Year	Semester	No difference
(a) better motivation			
300	22	25	17
301	14	26	14
9	42	25	18
(b) more student learning time			
300	53	8	5
301	36	13	7
9	67	6	12
(c) more student homework time			
300	49	9	8
301	33	12	9
9	62	10	11
(d) more content coverage			
300	49	6	9
301	32	9	14
9	63	9	14
(e) better student learning generally			
300	41	12	11
301	27	15	11
9	64	6	14

Grade 12 instruction in both courses is primarily total group instruction, about 6% indicating a predominance of individual or small group instruction. At grade 9 level about 20% fell into these latter categories. About 10% of grade 9 teachers also indicated that they taught two or more grade levels in the same class and 6% indicated an open-area teaching situation.

Classroom Activities

With respect to classroom activities similar questions were asked at the grade 9, 300, and 301 levels (items 8, 9, and 22 respectively). These data suggest that at grade 9 concrete materials are used infrequently, that individual work (often from textbook) and oral response are very frequently used. Work at activity centres is infrequent while teacher explanations and demonstrations are common. Small group work is carried out now and then. Opportunities to work on creative projects appear to be given rarely, but grade 9 teachers did provide review and drill on basic computation. At the grade 12 level the patterns were not greatly different, except that less correcting of papers by students took place at the higher level.

Use of Curriculum Guides, Textbooks, and Other Resource Material

At the grade 9 level more than 75% of the respondents found the 1979 7-9 Mathematics Curriculum Guide useful or very useful. Other Department of Education and division or school developed materials fell into the less than useful categories for at least 50% of respondents. Mathematics textbooks rated even higher in usefulness than the Curriculum Guide, and Teacher's Guides for textbooks were also rated rather highly. The only other resource which was rated as useful or better was material received through in-services and workshops.

The reasons for the high ratings of the Curriculum Guide are not hard to find in an item directed at views of specifics of the Guide (see questionnaire). Virtually everyone of the five aspects was rated 3 or better on a 5 point scale by at least 50% of the respondents. Thus the Guide has been found to be a useful document to the practicing classroom teacher.

In regard to textbook usage, the large majority used one textbook either exclusively or predominantly. Most felt that there should be several recommended textbooks from which the teacher could choose. No single text at this level has a majority of the market, although the most widely used is Math Is/3 (Ebos, et al.).

The Grade 12 curriculum guides in use at the time of the survey are those from 1974. For both the 300 and 301 courses about one quarter of the respondents found the Guides to be useful, the majority found them either minimally or not useful. Other support materials from the Department of Education or School divisions rated even less useful. Teachers of Math 300 rated textbooks useful or very useful, although Teacher's Guides for textbooks somewhat less so. The highest usefulness ratings other than textbooks were given to university courses and materials obtained through in-service workshops. Similar patterns obtained for Math 301 teachers, although all ratings were slightly lower, perhaps more tentative. Higher nonresponse rates were recorded for 301, reaching as high as 50%, whereas about one-third of the 300 teachers did not respond on these items.

Of those responding to an item on textbook use, more than half of the teachers in both

courses used one basic textbook. About the same proportions also felt that there should be several recommended texts to allow the teacher to choose. Virtually none indicated that there should be no prescribed textbook.

At the 300 level the Vance textbook (An Introduction to Modern Mathematics) was used as the basic or predominant text by over half of the responding teachers. Other listed texts were used as additional resources by about 20% of respondents. At the 301 level the picture is less clear. About 35% used Mathematics for a Modern World (Book 4) as the basic or predominant textbook. One other (Dean and Moore: Foundations of Mathematics) was used by 12%. No other textbook was indicated to be in wide use either as basic, predominant or as an additional resource.

Use of Calculators and Computers

About 20% of grade 9 respondents indicated that a computer was used in their school. Of these, 10% to 15% indicated that students were involved directly in the listed computer activities, including programming. Among Math 300 respondents 35% indicated the presence of a computer in their school. Not much more use was made of the computers in these schools than among grade 9 students. (In some cases these may be the same schools.) Math 301 teachers indicated that 25% had computers, but that use was minimal except that some used it for running pre-written programs.

In response to a question regarding the grade level of first calculator use, less than 20% at both grade levels indicated grades lower than 7. Grades 7, 9, and 10 attracted the most responses. On a list of types of calculator use, all uses received high "YES" ratings, although the high "NO" rating for "arithmetic calculations" is significant. All other "NO's" received less than 16%. Thus calculators received an overwhelming endorsement with one reservation. Grade 12 teachers had an additional question regarding the use of tables vs. calculators for topics such as logarithms, trigonometry, finance, and statistics. Over 30% of Math 300 respondents indicated that they should know how to use tables. Lesser numbers indicated that calculator use was sufficient. Except for a higher nonresponse rate, Math 301 teachers responded similarly.

Classroom Evaluation

The two evaluation techniques given major emphasis by most grade 9 teachers are teacher prepared classroom tests and teacher observation of day-to-day working habits. Teacher marking of daily work and teacher prepared tests for use throughout the school also rated highly. Commercial materials received little or no emphasis from the great majority. Almost identical patterns were recorded by grade 12 teachers.

Teacher Views of the Assessment Program

A number of questions were asked at each grade level in order to get teacher perception of the Mathematics Assessment Program. At the grade 12 level this necessitated three sets of items, one for the general test, and two parallel sets of Math 300 and 301.

For the 12-General test 85% of the respondents answered the two items. Two-thirds indicated 3 or better on the 5-point scale indicating satisfaction with the difficulty level of the test. About 70% indicated overall satisfaction, with a 3 or better rating. In both items

more than 40% rated the test 4 or higher.

For the 300 and 301 tests and the grade 9 test the same set of six items was used with a 5-point scale. In rating the match between tested skill areas and skills being taught, at grade 9 level 63% rated the match at 4 or higher, 80% at 3 or higher (there was less than a 10% nonresponse rate). At grade 12 the nonresponse rates were much higher: 39% for 300 and 54% for 301. Nevertheless, at the 300 level over 50% found the match satisfactory or better; this dropped to 40% for 301. Satisfaction with the difficulty level was over 80% at grade 9 level, over 50% for 300 and 35% (over 75% of those responding) for 301.

Overall satisfaction was rated 3 or higher by about 80% of grade 9 teachers, 50% of 300 teachers and 35% of 301 teachers. When asked if the assessment tests would be part of the instructional program evaluation, more indicated that it would not be used than the reverse.

In a question regarding the usefulness of the clusters in scoring the test, a majority indicated that clusters were useful for identifying strengths and weaknesses. This was true at both grade 9 and 12 levels. An overwhelming majority of respondents indicated that if skills were to be tested again this way in the future they would likely request enough copies for their entire class.

The responses to this set of items indicate a high level of satisfaction with the student testing program. Overall satisfaction was high and the scoring key was also found useful.

Curriculum and Instruction

Two further sets of items at each of the 300 and 301 levels aimed at determining teacher views on curricular content specific to each of the grade 12 courses.

Of the nine topics listed in a question regarding emphasis in the Mathematics 300 course, three were rated by a significant proportion suggesting less emphasis. These three were conic sections, logarithms, and double-angle trigonometry. The strongest response was for less emphasis on trigonometry. No topic received a strong "greater emphasis" rating.

Another item asked for a "usefulness" rating for each of eight areas in the "00" mathematics courses. Algebraic derivation, algebraic skills, and problem solving were all rated "useful" or "essential" by a very large majority. On the other hand, consumer mathematics and statistics were each rated as "unnecessary" or only "slightly useful" by a significant proportion of respondents. Except for these latter two topics, all others were seen as at least useful by a majority. The questionnaire did not permit reasons to be given for the choices made here.

An identical "usefulness" item was presented to the Mathematics 301 teachers with clearly different results. While algebraic skill development was seen to be important by all, algebraic derivation and formal proof were seen as less useful for the "01" courses. Problem solving and statistics were viewed as moderately useful while consumer mathematics was seen as "useful" or "essential" by a large majority.

On a question regarding what should be the main goals of Mathematics 301, the only alternative to receive any significant proportion of the responses was:

to provide a truly general mathematics option at the grade 12 level including a practical

study of statistics, consumer mathematics and vocational mathematics.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Grades 3 and 6

1. Virtually all elementary school mathematics teaching takes place in the self-contained classroom by the nonspecialist teacher. About 20% of these teachers are teaching more than one grade level within that classroom.

2. At both grade levels much time is spent in having students work individually, but both large and small group instruction are used. Students frequently mark papers--their own and others.

3. The 1978 curriculum guide, K-6 Mathematics, has been well received and is being used.

4. Teachers favor the current policy of several recommended textbooks from which they may choose.

RECOMMENDATION: That the present textbook adoption policy be continued.

5. The use of calculators received a favorable response, but clearly should not be used to replace the learning of basic arithmetic skills. Calculators should be used as a support tool in a variety of mathematics situations.

RECOMMENDATION: That calculator use in the elementary school be encouraged as a supportive tool in areas other than basic arithmetic skills.

6. The use or even presence of microcomputers was minimal at the time of the survey. In fact, most of the teachers suggested that computer assisted instruction (undefined) was relatively unimportant.

RECOMMENDATION: That computer education in its various forms be closely monitored as microcomputers become more available in elementary schools. Computer education should be encouraged.

7. Evaluation in the classroom follows traditional patterns with an emphasis on teacher made tests and day-to-day observation of students.

8. The student assessment program was well received. Teachers generally felt that the objectives tested and the difficulty level were appropriate. Most said that they would in the future opt to test their entire class. The Scoring Key with its clusters was also favorably received.

9. Better textbooks, more manipulative materials, and more time were some of the items which teachers saw as important to their mathematics instructional programs.

RECOMMENDATION: That school provide more manipulative and support materials for elementary mathematics.

Grades 9 and 12

1. A very low rate of questionnaire return raises a number of questions about the reliability of the data and the interest of teachers in providing professional input into curriculum and instruction decision making. At the grade 12 level this is a particular concern because the sample of respondents is split into two course groupings and the representativesness of these respondents is unknown.

2. The evidence is clear that teachers feel that less learning takes place in the semester system as opposed to the full year system.

RECOMMENDATION: That an in-depth look be taken at the semester system and the current time allotment for grade 12 courses as factors in mathematics achievement.

3. Individual work and lecture/demonstration are the primary activity within the classroom at both levels.

4. The curriculum guide, 7-9 Mathematics (1979), has been well received and used by teachers.

RECOMMENDATION: That this Guide or guides with similar characteristics continue to be available to junior high school teachers.

5. The current approach to recommended textbooks and teacher selection was favored by a majority of teachers.

RECOMMENDATION: That the current textbook adoption policy be continued.

6. Calculators were seen as a tool to be used, particularly in grades 7-10 of the secondary school. At grade 12 level teachers were divided on the use of the calculator as a substitute for the use of mathematical tables. (See also the recommendation under Mathematics 301, #2, Chapter VI. P.62).

RECOMMENDATION: That consideration be given to encouraging calculator use in grade 12 mathematics and to permit the use of calculators on all future grade 12 mathematics assessment tests.

7. Evaluation in the classroom follows traditional patterns with emphasis on teacher-made tests and daily observations of students.

8. The teachers viewed the assessment program and student tests favorably. The difficulty levels were seen to be appropriate and overall satisfaction was high on all four tests. Although most teachers indicated that in any future assessments they would choose to test their entire class, a majority said NO to making it a part of their instructional evaluation program. It should be noted here that anecdotal evidence from some teachers suggests that inclusion of such a test as part of the classroom evaluation program increases the liklihood of reliable results both for the teacher and the assessment program as a whole.

RECOMMENDATION: (See recommendation under #2, Mathematics 300, Chapter VI.)

9. At the mathematics 300 level three topic areas were recommended for a decreased emphasis and none for increased emphasis. In the "00" program as a whole there are clear splits in the goals of teachers. Those areas indicated as essential by some were exactly the same as those considered only slightly useful by others. Only three areas were identified strongly as useful to essential and one, consumer mathematics, was rated by a significant number as less than useful.

There is clearly concern over the content specified for Mathematics 300. In addition to the suggestions for decreased content, it was noted by a number of teachers that the time available for the course has been reduced from 18% to 12% of student time without a corresponding reduction in content. It was suggested that a return to 18% time should be considered.

RECOMMENDATION: That the objectives of Mathematics 300 be closely examined in the context of teacher expectations of students, university entrance requirements, time allotments and organization, the availability of calculators and/or computers and the amount of course time available for the specified content.

10. For Mathematics 301 no consensus was achieved in regard to some overall goal statement, but some common goals can be derived from the ratings given. Algebraic skill development and consumer mathematics both rated highly, while formal proof was thought unnecessary.

RECOMMENDATION: That the objectives of Mathematics 301 be closely examined in the context of teacher expectations of students, higher education and career goals of students, time allotments and organization, the availability of calculators and/or computers.

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

The mathematics assessment program was intended to provide provincial data about the level of student achievement in Manitoba to those responsible for the educational system. This chapter provides a condensation of the conclusions for each test administered and recommendations based upon a synthesis of the student achievement results and the teacher survey data.

STUDENT ACHIEVEMENT IN MATHEMATICS

Grade 3

Student performance was satisfactory on whole number computation in addition and multiplication, while on the inverse operations of subtraction and division it was weak. Students also experienced difficulty on word problems, often because they did not select the correct operation.

Interpretation of bar graphs was well handled, but the areas of geometry and measurement indicated both real strengths and real weaknesses. Linear measurement and nonnumerical geometry fared well, while numerical applications in geometry caused difficulty.

Grade 6

Basic computation with whole numbers was generally well handled, although zeros caused difficulties in particular types of multiplication and division exercises. The notion of place value in both whole numbers and decimal fractions appeared to be not well understood.

Work with prime numbers and prime factorization was not well done nor did students perform well on computation with fractions.

Although some understanding of symmetry and motion geometry was demonstrated, geometric terminology was poorly understood. While students were able to estimate the length of a crayon in centimetres, they were unable to make conversions of units within the metric system or to calculate the area or perimeter of a rectangle.

Grade 9

Grade 9 students were able to find the area and perimeter of a rectangular region, but otherwise showed little understanding of geometric concepts and terminology. They had real difficulties in applying the Pythagorean relation to find the length of a side of a right triangle.

Certain types of algebraic skills, such as simplification and substitution were well done, but others were at an unsatisfactory level. The weakest areas were exponents, terminology, and equation solving.

On basic operations with integers, fractions, and decimal fractions performance was marginal, and on operations with absolute value a weakness.

12-General

The generally satisfactory performance on consumer applications of mathematics and Graphing and Graphing and Statistics is encouraging. Performance by the group which had no grade 12 mathematics was not strong on basic operations with integers and percents, but all groups did well on recognizing appropriate use of everyday units in the metric system.

Geometry performance, except for the Mathematics 300 students, was considered weak. This finding is consistent with that at other grade levels.

Mathematics 300

Overall performance by Mathematics 300 students was disappointing. The results on the Permutations, Combinations, and Binomial Theorem subtest were very satisfactory, while performance on Exponential and Logarithmic Functions, Trigonometry, and Trigonometric Identities were satisfactory. On the remaining five topic areas performance was considered marginal.

A number of factors undoubtedly affected the performance and some of these are discussed in the report of the Mathematics 300 results and are evident in the recommendations.

Mathematics 301

Performance by Mathematics 301 students in the topic areas of Sequences and Exponents was considered satisfactory. Results in the other required areas were marginal. In the option topics of Interest and Annuities, Mathematics of Chance, and Statistics, performances were rated marginal, marginal, and unsatisfactory, respectively.

Trends Across Grade Levels

Performance in Geometry and Measurement was disappointing across all grade levels. While a few bright spots can be identified, the general conclusion is one of weakness in these areas.

The Manitoba results in the early grades indicate only slight differences between males and females, a finding that differs somewhat from trends identified in other North American studies where males perform better than females. This trend only becomes apparent at the grade 12 level in the Manitoba results. No specific recommendation is presented at this time, although this aspect should be monitored in future assessments.

RECOMMENDATIONS

The recommendations presented here are based upon a synthesis of the mathematics achievement results on six tests at four grade levels in conjunction with the results of the teacher survey conducted at the same four grade levels. They are not an exact repetition of the recommendations found in the earlier chapters, but a synthesis of them.

Future Mathematics Assessments

1. That the provincial assessment of mathematics achievement be an ongoing activity of the Department of Education, assessments should be repeated periodically in the coming years.
2. That in future assessment programs, teachers be strongly encouraged to incorporate the assessment tests into their instructional evaluation programs. Many students do not put forth their best effort unless the assessment has direct importance to them.

3. That students in Mathematics 300 and Mathematics 301 be permitted to use electronic calculators in future mathematics assessments.
4. That assessment programs be designed to collect student demographic data and data on classroom practices and teacher background for purposes of analysis with student achievement data.

Teacher Training and Professional Development

1. That teachers be encouraged and given time and support to participate in professional development and updating activities.

Teacher Qualifications

1. That the teacher training institutions consider requiring at least one course in the teaching of elementary school mathematics and at least one course in mathematics for teachers for all elementary education graduates.
2. That school divisions ensure that all teachers teaching mathematics possess at least the background in Mathematics equivalent to that required for undergraduate certification programs in the subject at provincial universities.

Teacher Resources and Equipment

1. That schools be urged to supply, and teachers to use, more supporting manipulative and reference material in elementary mathematics.
2. That the present textbook adoption policy of teacher selection from among authorized texts be continued.
3. That the present curriculum guide, 7 - 9 Mathematics (1979), or guides with similar characteristics, continue to be available to junior high mathematics teachers.
4. That the present curriculum guide, K - 6 Mathematics (1978), or guides with similar characteristics, continue to be available for elementary mathematics teachers.

Curriculum and Instruction: General Recommendations

1. That topics in geometry and measurement receive more attention in the classroom and in professional development.
2. That teachers and school divisions examine the teaching of geometry and measurement with a view to insuring that at least the specified curriculum is taught in grades 1 - 11.
3. That an indepth review be conducted of the semester system as a factor in mathematics achievement at the high school level.
4. That, at each grade level, concepts and skills from earlier grade levels be part of ongoing review, in part by embedding them in a problem solving context.
5. That the use of calculators in the elementary school be encouraged as a supportive tool in areas other than basic arithmetic.
6. That computer education in its various forms be closely monitored as microcomputers become more available at all levels, including the elementary school. Computer education should be encouraged.

7. That teachers select correct mathematical terminology and that this be used in the classroom.
8. That the current trend toward more emphasis on problem solving activities be continued and encouraged.

Further, specific recommendations directed primarily to teachers, schools, and divisions were made at each grade level. Only the recommendations made in addition to those listed above are reported in this section.

Grade 3

1. That subtraction and division receive appropriate attention by teachers and that they be taught as inverse operations of addition and multiplication respectively.
2. That more emphasis be placed on applications. In some cases this may mean more time, but alternative approaches should also be considered, e.g., embedding application in review.
3. That more emphasis be placed on patterns, i.e., on discussions about the relationships between numbers

Grade 6

1. That the topic of place value be reviewed at each grade level and that students be given practice in estimating results.

Grade 9

1. That students be given more opportunities to do practical problems involving Pythagorean Theorem.
2. That the curriculum guide, 7 - 9 Mathematics (1979), be followed by teachers and that core topics given in the guide be given priority over option topics.

Mathematics 300

1. That the following be reviewed: 1) the mathematical background required for a student to be successful in Mathematics 300, and 2) the counselling of students to enroll in Mathematics 300.
2. That the objectives of Mathematics 300 be closely examined in the context of teacher expectations of students, university entrance requirements, time allotments and organization, and the availability of calculators and/or computers.
3. That teachers stress the properties of logarithmic and exponential functions over computations (which can be readily performed with a calculator).
4. That teachers review the method they are using for the simplification of trigonometric expressions and consider alternative approaches.*
5. That teachers review their teaching of Progressions, and supplement the topic with additional exercises if the text they are using has a limited number of practice problems.
6. That teachers place more emphasis on oral responses to variation problems.

Mathematics 301

1. That the objectives of Mathematics 301 be closely examined in the context of teacher expectations of students, higher education and career goals of students, time allotments and organizations, and the availability of calculators and/or computers.

* One approach considered effective is that of the Fisher and Ziebur text: Integrated Algebra and Trigonometry with Analytic Geometry.

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